

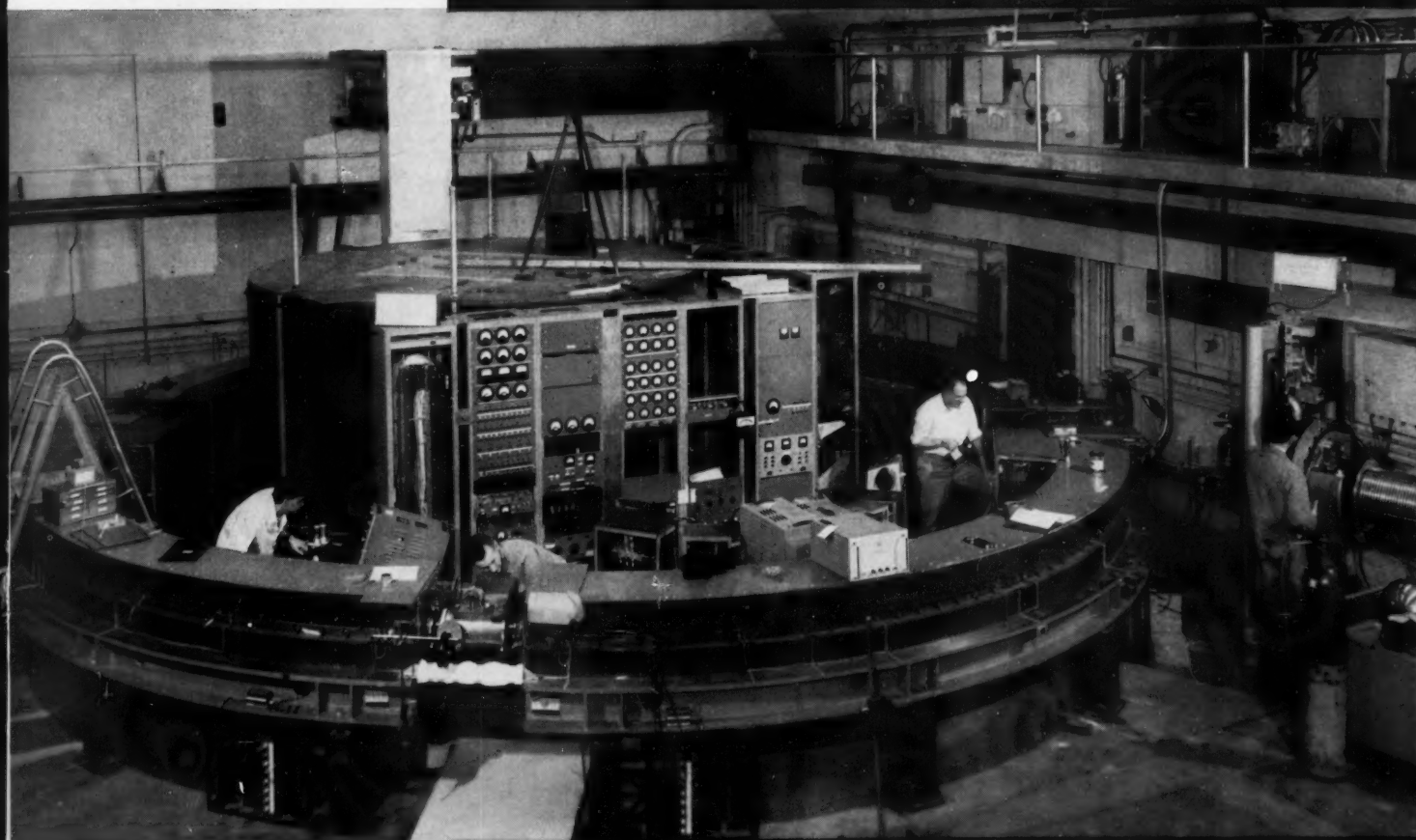
COLLEGE OF ENGINEERING

CORNELL UNIVERSITY

University Microfilms
313 N. First St.
Ann Arbor, Mich.

the Cornell

engineer



MAY, 1955
VOL. 20, NO. 3
25 CENTS

James Chisholm, class of '41,
speaks from experience when he says,

“Men with ability and ambition really have
a chance to get ahead at U.S. Steel”



● A responsible position can come quickly to those graduate engineers at U.S. Steel who show ability and ambition. Management training programs are designed to stimulate and develop these qualities as the trainee “learns by doing.” His training is always a fascinating challenge and he works with the best equipment and the finest people in the business.

James Chisholm is typical of the young men who rapidly rise to an important position at U.S. Steel. Jim came to U.S. Steel as a trainee in 1941 after graduating as an M.E. Shortly thereafter he entered military service for four years. Upon his return to U.S. Steel in 1946, he advanced steadily until, in 1951, he was appointed to his present position as Assistant Superintendent of Blast Furnaces at the new Fairless Works at Morrisville, Pa.

Jim is now in charge of the unload-

ing of all ore ships and the operation of the plant's two big blast furnaces—each with a rated output of 1500 tons per day.

Jim feels that the opportunities for graduate engineers are exceptional at U.S. Steel. He remarked that in his own department alone, six college trainees have been put into management positions within the last couple of years. He says that chances for advancement are even better now with the current expansion of facilities and the development of new products and markets.

If you are interested in a challenging and rewarding career with United States Steel, and feel that you can qualify, you can get details from your college placement director. And we will gladly send you a copy of our informative booklet, “Paths of Opportunity,” which describes U.S. Steel and the openings in various scientific fields. Just write to United States Steel Corporation, Personnel Division, Room 1622, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

SEE THE UNITED STATES STEEL HOUR. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.



UNITED STATES STEEL

AMERICAN BRIDGE .. AMERICAN STEEL & WIRE and CYCLONE FENCE .. COLUMBIA-GENEVA STEEL .. CONSOLIDATED WESTERN STEEL .. GERRARD STEEL STRAPPING .. NATIONAL TUBE
OIL WELL SUPPLY .. TENNESSEE COAL & IRON .. UNITED STATES STEEL PRODUCTS .. UNITED STATES STEEL SUPPLY .. Divisions of UNITED STATES STEEL CORPORATION, PITTSBURGH
UNITED STATES STEEL HOMES, INC. • UNION SUPPLY COMPANY • UNITED STATES STEEL EXPORT COMPANY • UNIVERSAL ATLAS CEMENT COMPANY

S-690



MUCH MORE THAN MEETS THE EYE GOES INTO DOW PACKAGE DESIGN

Engineers and ocular cameras, salesmen, lawyers and artists combine talents to produce a unified "sales team" for Dow

Tin cans and tank cars, cardboard cartons and fiber drums, bags and bottles of sundry shapes, carry Dow products to world markets. In addition to quickly describing its contents, each package should speak for the product's quality and should reflect the company which produced it. Dow recently redesigned its packages with these objectives in mind.

Developing effective design while maintaining family resemblance for hundreds of Dow products was not an easy task. The abilities of hundreds of people and many machines were involved. Designers, engineers, salesmen, lawyers and artists all were called upon to contribute their particular knowledge.

An ocular camera played a vital role in choice of design. A subject sits before the camera and the test package is briefly exposed. Meanwhile, a moving picture is made of the subject's eyes. The picture is printed and played back,

giving an accurate record of how the package was scanned. When analyzed, these pictures show which design elements dominated, the order in which the product message was read and so forth. The result—an accurate test of whether the package is doing its job, unimpaired by undependable personal likes and dislikes.

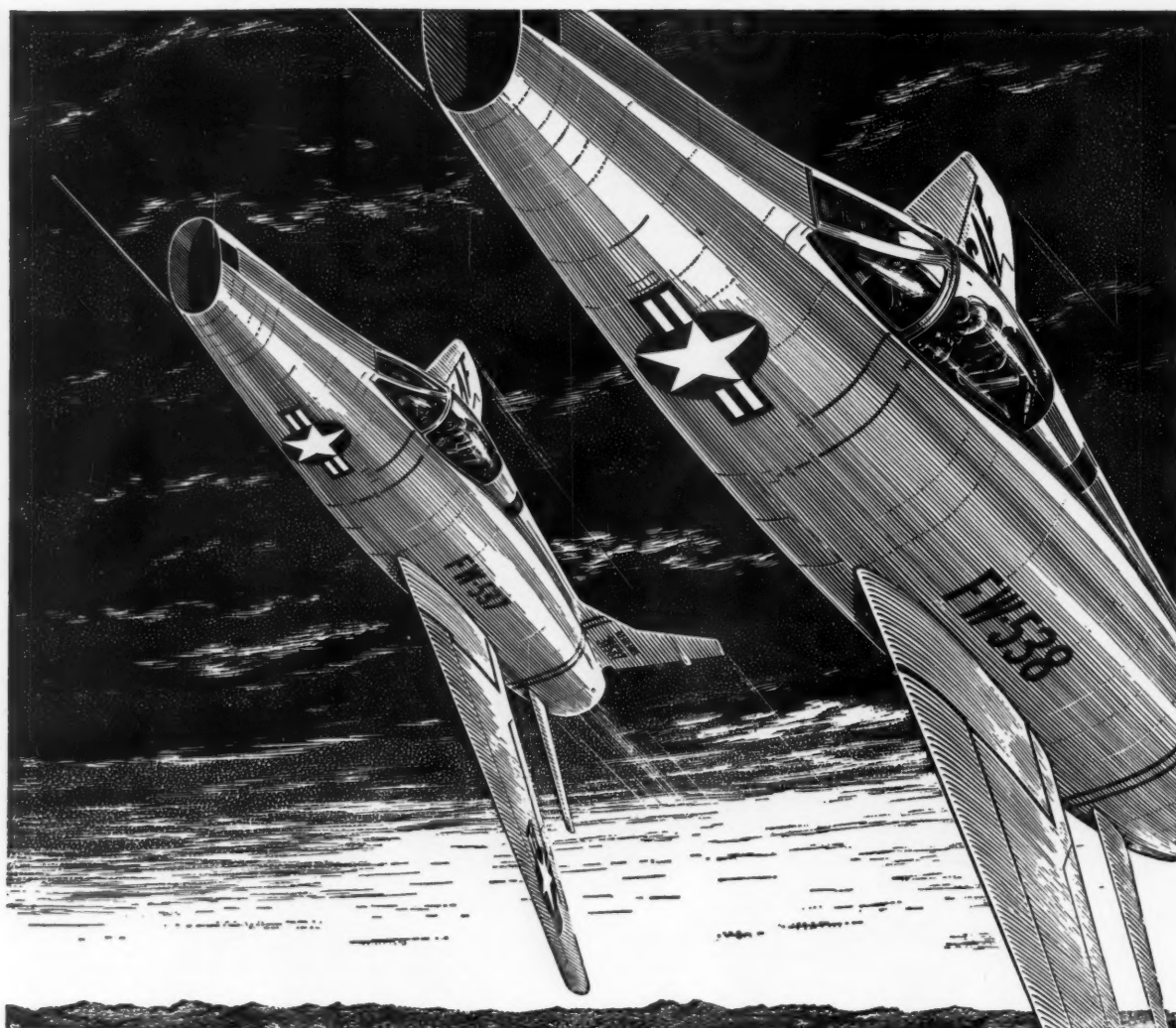
The design chosen and printed, thousands of packages leave Dow plants daily selling Dow quality and dependability to the world. Package design is a big job, yet it's but one step in a product's progress from research laboratory to customers' hands.



Whether you choose research, production or sales, you can find a challenging career with Dow. Write to Technical Employment Department, THE DOW CHEMICAL COMPANY, Midland, Michigan or Freeport, Texas for the booklet "Opportunities with The Dow Chemical Company"—you'll find it interesting.

you can depend on DOW CHEMICALS





FOR UNLIMITED OPPORTUNITY...

JOIN THE TEAM THAT BUILDS THE F-100

North American's new F-100 Super Sabre is the supersonic result of engineering minds designing where opportunity is unlimited. The same opportunity exists for you . . . because North American knows your future is important to aviation's future . . . that your talent and training are vitally needed to help design tomorrow's aircraft.

North American needs men with vision and a thorough technical background to help create and shape the new ideas which will build the advanced aircraft and aircraft components needed to assure America's future in the air.

Engineers at North American also find opportunities in the expanded programs in atomic energy, rocket engines, advanced electro-mechanical equipment and guided missiles. When the time comes for you to enter the engineering profession, consider the well-paid careers at North American. Write for information concerning your future in the aircraft industry.

Contact: Your college placement office or write: Employment Director,

5701 West Imperial Highway
Los Angeles, Calif.

12214 South Lakewood Blvd.
Downey, Calif.

North American Aviation, Inc.
Columbus 16, Ohio



ENGINEERING AHEAD FOR A BETTER TOMORROW

NORTH AMERICAN AVIATION, INC.

A Campus-to-Career Case History



"This is what I did yesterday"

"I like a job that keeps me jumping," says Bill Jermain, C.E. from Marquette, '52. "And my first management assignment with Wisconsin Telephone Company does just that. I'm Service Foreman at Sheboygan, with nine installers, and that means variety of responsibility. But judge for yourself. Here's a quick run-down of what I did yesterday, on a typical day—

8:10—"Checked day's work schedule. One of my new men was putting in a buried service wire, and I went over the job specs with him to be sure he had things straight.

8:30—"Answered mail while my clerk checked time sheets from previous day.

9:30—"Out to supervise installation of the first aluminum Outdoor Telephone Booth in my exchange. Reviewed the assembly instructions with

the installers, then arranged for special tools and bolts to be delivered to the job.

11:30—"Drove across town. Made a 'quality inspection' on a telephone installed last week. Everything checked O.K.

12:00—"Lunch.

1:00—"Picked up film for next day's safety meeting. Watched the film, made notes for discussion.

2:00—"Met with moving company manager to estimate cost of telephone cable lifting for a house moving job. Drove the route he had planned and worked out schedule for construction crews.

3:30—"Returned to aluminum booth installation. Went over wiring specs with the electrician.

4:00—"Stopped at Central Office to pick up next day's orders. Met installers at garage as they checked in and assigned next day's work."

Bill has been in his present job about a year, and is looking forward to new responsibilities as his experience increases . . . as are the many young college men who have chosen telephone careers. If you'd be interested in a similar opportunity with a Bell Telephone Company . . . or with Bell Telephone Laboratories, Western Electric or Sandia Corporation . . . see your Placement Officer for full details.



**BELL
TELEPHONE
SYSTEM**

EDITORIAL

"Volume 20 Number 8" marks the final publishing act of the CORNELL ENGINEER for the school year of 1954-55. During the months soon to follow, major plans will take shape in preparation for next year's series, which we believe you will find interesting and appealing.

In addition to thanking our readers for the many useful critical remarks we have received throughout the past year, the staff wishes to present informally the following specific comments on "Reader Communication". We hope you will make serious consideration of these comments.

First:

Beginning with the October issue we expect to maintain a "Letters to the Editor" section, in which each month two or three of our readers' letters will be published for the hopeful purpose of stimulating cri-

ticism of the material presented in our feature article (and of the feature articles themselves), as well as in other divisions of the magazine. We invite you to help us make this a useful addition.

Second:

Occasionally (but not frequently) we receive correspondence from readers who suggest specific topics for our editorial board to consider in choice of articles. The subjects so suggested often prove unusually interesting.

Furthermore, many of our readers are in a position to recognize or know about certain subjects important or interesting to others, while they themselves very often lack the time necessary to either write the articles or to locate all the facts. It is of course our business to have the time, and the facilities, to do both. Therefore we invite an in-

creased frequency of suggestions of this kind.

Third:

While many of our articles are written by the students on our staff, articles by others are often included in the ENGINEER. The "others" are alumni, students not on the staff (two such articles in this issue), and faculty members.

The opportunity is available to these people to volunteer their services as writers, at any time! Open-minded as we are, we will accept suitably prepared articles on almost any subject. The stipulation is that the subject be in some way related to science or engineering. And be it recognized that today, even politics is (and religion is, or should be) related to these subjects. "If you know something useful, write it down."

We suggest that in preparation for the writing of the article you communicate with us, so as to obtain more precise information about length, illustrations, etc., thus avoiding unnecessary "mis-guesses".



Manufacturers of Super-Refractories Only



REFRACTORY CRUCIBLES

GRAPHITE CRUCIBLES

HIGH TEMPERATURE CEMENTS

SPECIAL REFRACTORY BRICK, TILE, SHAPES



From the Following Materials:—

GRAPHITE — SILICON CARBIDE — FUSED ALUMINA — MULLITE

MAGNESIA

ZIRCON



LAVA CRUCIBLE-REFRACTORIES CO.

PITTSBURGH, PA.

Another page for

YOUR BEARING NOTEBOOK

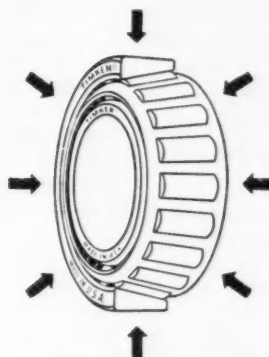
How to increase gear life in a scraper



When this 13 cubic yard scraper, fully loaded, travels at 25 MPH over rough terrain, the gears in the differential, engine shaft and pinion get a workout. Realizing this, the engineers specified Timken® bearings for these vital applications. The tapered construction of Timken bearings lets them take radial and thrust loads in any combination. Gears are held rigidly in place. Perfect tooth-mesh is maintained. Gears last longer.

How TIMKEN® bearings hold gear shafts rigid

The line contact between rollers and races of Timken bearings gives shafts rigid support over a wide area. Shaft deflection is minimized. And the tapered design of Timken bearings permits them to be set up with the most desirable amount of end play or preload that gives the best performance.



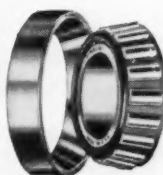
Want to learn more about bearings or job opportunities?



Some of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on

Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, O.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ◯ THE TIMKEN TAPERED ROLLER ◯
BEARING TAKES RADIAL ◊ AND THRUST — ◊— LOADS OR ANY COMBINATION ✱

The Torrington Needle Bearing

...designed for easy, effective lubrication



One major advantage inherent in Needle Bearing design is the ease with which the bearing can be lubricated.

The full complement of small diameter rollers continuously carries a thin film of lubricant to all contact surfaces. The turned-in lips of the outer shell retain the lubricant and effectively seal out foreign matter.

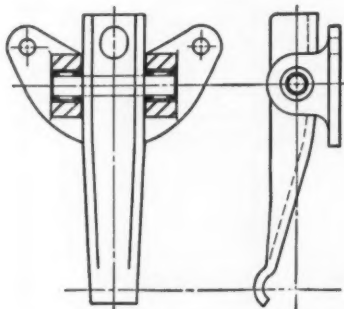
Methods of Lubrication

When Needle Bearings are shipped, they are normally protected with a high-grade slushing compound which has lubricating value at ordinary temperatures. This compound is left in the bearings in most instances. Needle Bearings in many applications run for long periods of time without further attention to original lubrication.

There are several methods of providing additional lubricant to Needle Bearings, as illustrated and described below.

PERMANENT LUBRICATION

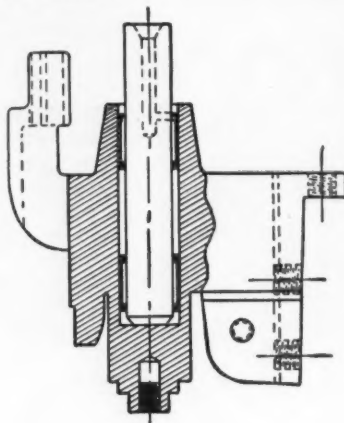
For low speed and light load applications, as in the fingers of the automobile clutch illustrated, the Needle Bearings are packed with grease before assembly. No additional lubrication is needed.



THROUGH THE SHAFT

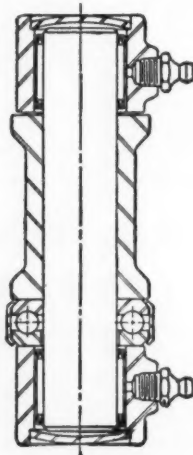
If it is necessary to lubricate through the shaft, a hole is drilled along the shaft axis, with a cross hole leading under the lips of the Needle Bearing. This hole is located

under the lip of the bearing rather than in the roller contact area. Textile machine spindle swing bracket below illustrates this method.



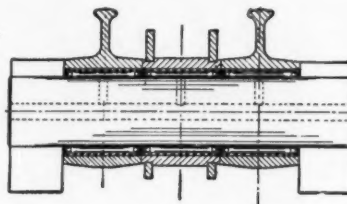
THROUGH THE HOUSING

When lubricant is to be delivered through the housing, an oil hole is furnished in the middle of the outer shell. In automobile king pin below, Needle Bearings are lubricated with Alemite fittings through the oil hole. This oil hole in the outer shell should be outside the load area.



CIRCULATING OIL SYSTEM

For high speeds and heavy loads, a circulating oil system is preferred as it aids in carrying away heat as well as in providing a continuous supply of lubricant to the bearing contact surfaces. A typical example of this method is shown in this Needle Bearing application in the valve rocker arm of a large diesel engine shown below.



Selecting A Lubricant

While oil is the best lubricant, it is difficult in many cases to retain it in the bearing housing. In general, a soda base grease is used in the absence of moisture, and a lime base grease when moisture is present. It is usually advisable to consult a grease manufacturer regarding a particular application.

These features make the Torrington Needle Bearing Unique

- low coefficient of starting and running friction
- full complement of rollers
- unequalled radial load capacity
- low unit cost
- long service life
- compactness and light weight
- runs directly on hardened shafts
- permits use of larger and stiffer shafts

THE TORRINGTON COMPANY

Torrington, Conn. • South Bend 21, Ind.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON NEEDLE BEARINGS

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS

F. Barrett De Gress ME '57
editor-in-chief
Lavonne C. Olson ChemE '57
managing editor
Leonard Pisnoy CE '57
business manager

Publication Board

Richard Brandenburg EP '58
assistant editor
Arthur H. Vaughan EP '57
associate editor
Matthew C. Starr EP '57
illustrations editor
Bennett Brown CE '58
treasurer
Jack K. Warren ME '57
circulation manager
Yale Brazel EE '56
advertising manager
Jerome R. Quinn CE '57
publicity manager
Roger K. Fisher ChemE '57
office manager

Editorial Board

J. F. Ahearne EP '57
P. Crimi ME '58
F. F. Walsh ChemE '59
J. M. Walsh ChemE '59

Business Board

A. P. Perlman CE '58
S. M. Golder EE '59
H. R. Gordon ME '59
D. N. Koppes CE '59
H. M. Schamager EP '57
M. J. Surtes EE '58

Illustrations Board

S. G. W. Beck EE '56
R. C. Glover ME '55

Advisory Board

Dean S. C. Hollister

Technical Advisers

Prof. W. H. Erickson
Prof. J. E. Hedrick

School Directors

Prof. C. R. Burrows EE
Prof. N. A. Christensen CE
Prof. F. H. Rhodes ChemE
Prof. L. P. Smith EP
Prof. H. J. Loberg ME
Prof. O. C. French AgrE

Alumni

H. H. Williams, Jr. C.E. '26
W. H. Hill M.E. '22
I. B. Margiloff Chem.E. '53

Member of The Engineering College Magazines Associated

Chairman: Prof. Thos. Farrell, State University of Iowa, Iowa City, Iowa

Publishers' Representative, Littell-Murray-Barnhill, Inc., 101 Park Ave., New York and 605 N. Michigan Ave., Chicago

Founded 1885

THE CORNELL

engineer

MAY, 1955

VOLUME 20

NO. 8

EDITORIAL 4

THE NATURE OF LIGHTNING 9

Intensive research on the phenomena of electrical storms has been stimulated by the costly effects lightning can have on the property of power-system operators.

by Leon Hall, EE '55

STEELMAKING PROCESSES 14

"A History of Steelmaking in America", by the brother of this author, was presented last month. Now some interesting details on fast-developing modern methods are given. Among them: the Linz Donawitz Process.

by John M. Walsh, ChemE '55

CYCLONITE 18

Known to the military as "RDX", this compound, appearing under the microscope as colorless orthorhombic crystals, has explosive properties which are of great interest to organic chemists, engineers, and generals.

by C. V. Chester, Chem E '56

THE NEW ELECTRON—SYNCHROTRON 29

CORNELL: PIONEER IN DYNAMO DEVELOPMENT 41

by Richard Brandenburg, EP '58

THE PRESIDENT'S MESSAGE 32

ALUMNI ENGINEERS 33

CORRECTIONS OF AN ERROR IN APRIL ISSUE 36

COLLEGE NEWS 47

TECHNIBRIEFS 54

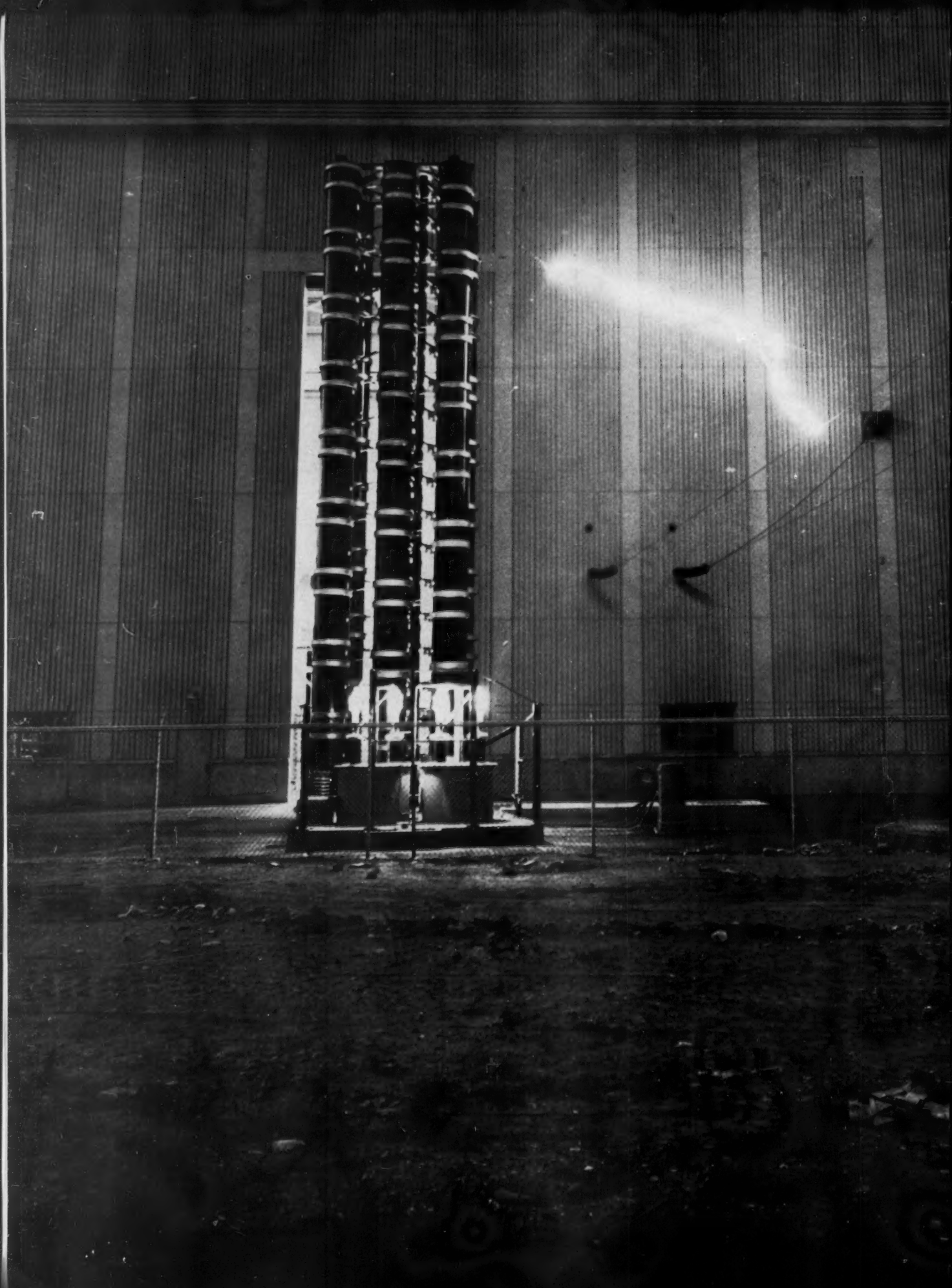
GRADUATING CLASSES: CHEM.E. AND E.P. 58

INDEX TO VOLUME 20 64

COVER: Cornell's nearly-completed electron synchrotron
(See page 29)

Published monthly—October to May—by the CORNELL ENGINEER, Inc., Lincoln Hall, Ithaca, N. Y. Edited by the undergraduates of the College of Engineering, Cornell University. Entered as second class matter at the Post Office at Ithaca, N. Y., under Section 103, Act of October 3, 1917.

Subscription per year: regular \$2.00; with membership in the Cornell Society of Engineers \$3.00 (See President's page); student \$1.50; single copy \$.25.



The Nature of Lightning

by LEON HALL, EE '55

(Photographs from General Electric Corporation)

The scene of Fig. 1 is one which is re-enacted a great deal more often than we probably realize. During the months of July and August, when thunderstorms occur most often, the United States will be struck by lightning three times every second. And for the entire earth, the rate is about 100 strokes per second.

Lightning, although it gives us some spectacular displays, is an unwelcome phenomenon in most quarters; it is the fourth most frequent cause of fires and does over nine million dollars worth of property damage annually. This last figure does not include the costly effect lightning can have on electric power systems; however, it is this facet of its behavior which has inspired practically all of the extensive research into its source and nature.

The interest that power system operators have in this field lies in the fact that lightning is potentially a major cause of interruptions in service. The job of a power system is to provide a continuous flow of power to its connected loads; interruptions are always inconvenient and can be very costly to the consumer and hence to the seller of electric power. If an industrial customer, for instance, was using electricity to run a continuous process such as melting metal, a failure of more than momentary duration would allow the process to freeze, leaving the customer with a mess to clear up before he could restart his operation.

Lightning produces outages on unprotected power systems in two ways—either by damaging equipment or by creating a short circuit. The former can be achieved by huge voltages and currents which will respectively break down insulation and produce mechanical forces large enough to wreck wind-



Fig. 1. Natural lightning strokes photographed from G.E. Pittsfield lightning observatory over a period of ten minutes on Aug. 23, 1938.

ings in a transformer or a generator.

A short circuit may occur as a phenomenon called flashover, which without destroying certain insulators, makes them ineffective. Overhead transmission lines are suspended from their supporting towers and isolated from ground by strings of porcelain insulators which are made necessary by the fact that the towers are purposely well grounded. Flashover takes place when an abnormally high voltage, which may well appear on the line because of a lightning stroke, is sufficient to break down the air surrounding the insulating string and therefore starts an arc between the line and the grounded tower. An arc is a good conducting path, so it acts as a short circuit which diverts the transmission line current to ground, thus interrupting the flow of power. A similar short or "ground fault" may result from a stroke which strikes a line between two towers and then jumps directly to the earth.

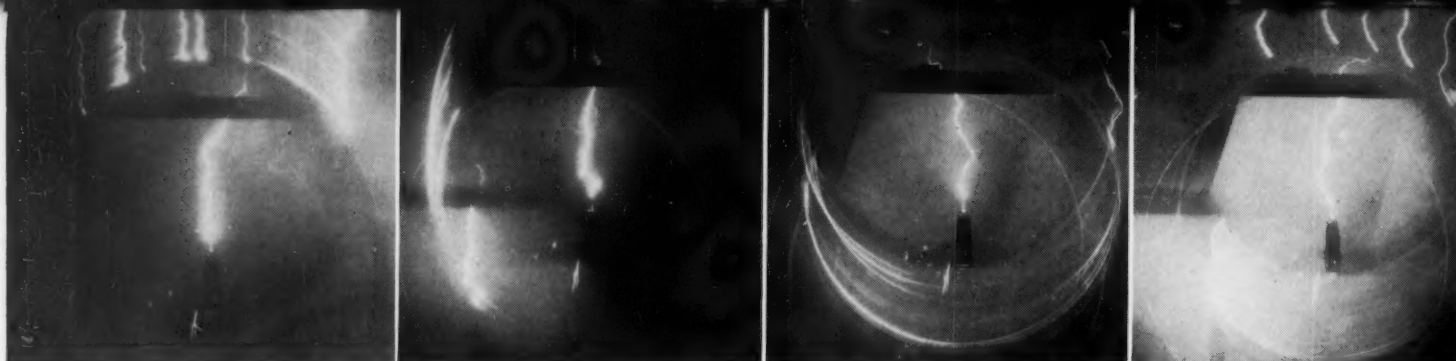
Protective devices have been built which will prevent these events in nearly every case, but to do this engineers have had to gain

some understanding of the elemental phenomenon of lightning. Before discussing their discoveries, it is appropriate to mention some of the names and methods of a few men whose work has been most important.

Franklin Pioneers Lightning Study

Certainly the best known contributor to the field was Benjamin Franklin, whose kite experiment in June, 1752, verified his theory that lightning is electric in nature. This pioneering demonstration won well-deserved fame for Franklin in spite of the fact that we know today that he drew from it an incorrect conclusion about the operation of lightning rods and that playing with lightning that way might easily have killed him. He was wrong in thinking that lightning rods prevent strokes by draining the charge from clouds, but, as we shall see later, they do afford some protection. He included a practical essay on this subject in "Poor Richard for 1753," and lightning rods immediately sprang up in a manner probably similar to that of today's television aerials. He was violently opposed in this matter by some New

An impulse generator at G.E.'s High Voltage Laboratory hurls a 7,500,000 volt lightning bolt at a length of a test power transmission line as a part of lightning protection research.



Stroke No. 13—9:43 P.M.

Stroke No. 14—9:44 P.M.

Stroke No. 15—9:48½ P.M.

Stroke No. 16—9:52 P.M.

Fig. 6. Eight strokes hit Empire State Building in twenty-four minutes.

England clergymen, who thought Franklin impious when he tried to prevent lightning strokes, which they imagined to be hurled from the wrathful hand of God instead of obeying natural laws.

Lightning Strokes Investigated

The number of investigators in this field has grown with the electric industry, and the work has been marked by cooperation between countries and between rival companies. Our knowledge of the mechanism of the lightning stroke is largely due to the work of B. F. J. Schonland from 1933 to 1937 in South Africa, where he obtained some important information from photographs.

The Empire State Building, a popular target for lightning strokes, was used by K. B. McEachron from 1935 to 1942 as a laboratory where more photographs were obtained and interpreted (see Fig. 6). He also connected oscillographs and peak current measuring instruments to the Building's mooring mast to obtain data. At the same time, more natural lightning photographs were being taken for study by J. H.

Hagenguth at Pittsfield, Massachusetts.

Work on the phenomena occurring on transmission lines and in connection with some protective devices has brought out the names of C. L. Fortescue, L. V. Bewley and F. W. Peek. Their investigations were in some cases made with the aid of artificial lightning created by impulse generators (see Fig. 8) in which lightning currents and voltages are simulated by discharging capacitors. No less important were Bewley's mathematical investigations of traveling current and voltage waves on transmission lines.

Special Instruments Developed

The problem of measuring the large currents and voltages made necessary the development of some new instruments. J. F. Peters invented the klydonograph in 1924; this device has two electrodes with a photographic film between them and a pattern called a Lichtenberg figure, which has a shape and configuration which is a function of the measured voltage, shows up on the film. Current is measured by magnetic links and the surge-crest

ammeter. Magnetic links are small lengths of iron which are held in brackets near a conductor where lightning current is expected to flow. The links are originally demagnetized, so a passing current in the conductor will leave residual magnetization in them; the surge-crest ammeter uses this property to determine the peak value of the current.

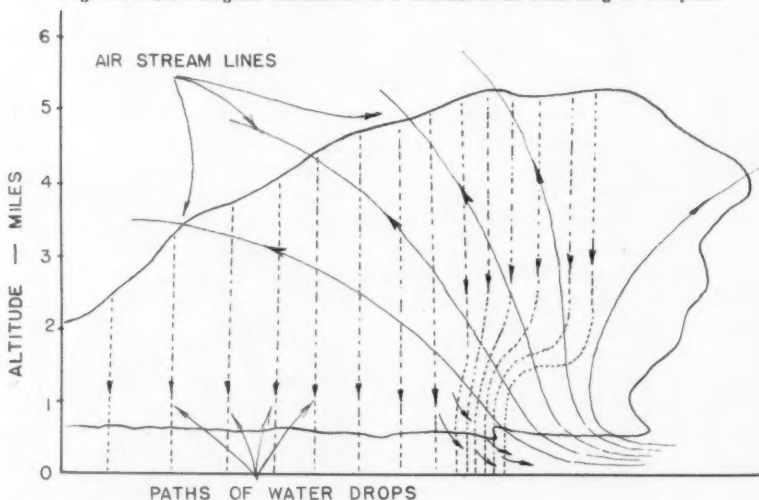
The photographs by Schonland and his contemporaries were taken with one of the two types of Boys Cameras, the original being introduced by Charles V. Boys in 1900. The high-speed type is shown schematically in Fig. 9. If the film drum is stationary the images of the line AB will be *ab* and *a'b'*; but when the drum rotates, the images will be distorted to *ac* and *a'c'*. This instrument was used to take the pictures in Fig. 5, and in such pictures the amount of distortion indicates the velocities. The low-speed Boys Camera, which made the photographs in Fig. 6, has two lenses in the same plane with parallel axes; one lens is stationary and the other rotates around it, their axes remaining parallel.

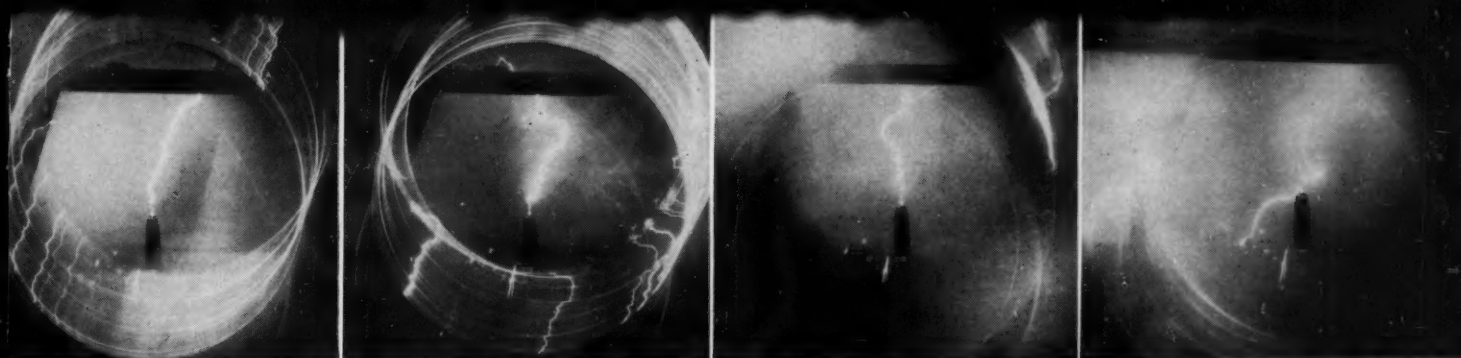
Theories Explain Cloud Charging

The beginning of a lightning flash is usually, of course, in a thunderstorm; the earth's atmosphere experiences an average of 44,000 of these every day. In some manner a cloud becomes electrically charged, the earth beneath it acquiring an equal and opposite charge. The problem here becomes one of meteorology as well as electrostatics.

Although it is evident that the violent air currents usually associated with lightning storms play an essential part in cloud charging, this remains a controversial topic today. A number of theories and variations have been advanced to

Fig. 2a. Meteorological conditions in a thundercloud according to Simpson.





Stroke No. 17—9:57 P.M.

Stroke No. 18—9:59 P.M.

Stroke No. 19—10:04 P.M.

Stroke No. 20—10:07 P.M.

explain the mechanism. Three of these are most widely accepted.

Breaking Drop Theory

The "Breaking-Drop Theory" of G. C. Simpson was developed in 1927 after first being suggested in 1909. It depends on the experimentally observed fact that when a water drop breaks apart in air the water "fragments" gain a positive charge while negative ions are released into the air.

Figure 2(a) shows a typical storm cloud with its characteristic upward air stream which is the drop-breaking agent in this theory. A drop of water which is falling freely in air will become unstable and will break apart when it reaches a certain size and "end velocity," and this, says Simpson, is what happens to drops in the upward air stream in the cloud. As has been said, the breaking is accompanied by a separation of charge. The result is shown in Fig. 2(b); the positive water fragments are blown upward, but by recombination with others they become large and begin to fall again. They retain their positive charge when this happens, while negative ions are carried farther up in the cloud by the air current. Thus Simpson arrived at the charge distribution shown, and his measurements of the polarity of the charge on raindrops during storms confirmed his ideas about the lower regions of the cloud.

Influence Theory

Elster and Geitel proposed the "Influence Theory," which makes use in a different way of the rising air currents. These men are concerned with the influence of the normally negative charge of the earth upon raindrops. By induction, the earth's charge results in the bottom of a water drop in a cloud having a positive charge, the top

region of the drop being negative.

The rising air stream is said to force small drops to ascend while the larger, heavier ones descend. In this situation the only possible collision between drops consists of the top of the small drops contacting the bottom of the large ones. Therefore, the small drop loses negative charge to the large one, and gains an equal positive charge. As this process continues, then, the bottom of the cloud becomes negative since it is richer in large and more negative drops; and the small positive drops similarly cause a positive charge to appear at the top.

Ionization Theory

In his "Ionization Theory", a third promising idea, C. T. R. Wilson says that each unit volume of air contains a number of positive and negative ions of varying size and mobility, and their number increases in a thundercloud due to the strong electric fields present there.

Wilson, too, considers the polarized drops of water rising or falling

through the cloud; as the falling drop, with its positively charged bottom overtakes the ions, it repels the positive ones. But it picks up negative ions and gradually gains a negative charge, as do the lower regions of the cloud. To intensify the effect, this lower negative charge increases the polarization of the drops above it, tending to perpetuate the separation of charge. At the same time the ascending smaller drops also meet positive and negative ions, the negative top of the drop attracting the former and repelling the latter. It thus acquires a positive charge as it drifts to the cloud's upper region and joins the particles accumulating there, aiding in keeping the process going.

A comparison between Wilson's theoretical charged cloud and that of Simpson shows a point of direct conflict—Simpson predicts a region of positive charge at the lower head of the cloud which does not appear in Wilson's picture. In an attempt to clear up this matter Simpson and Scrase used balloons to make sounding of electric fields in thun-

Fig. 2b. Electrical conditions.

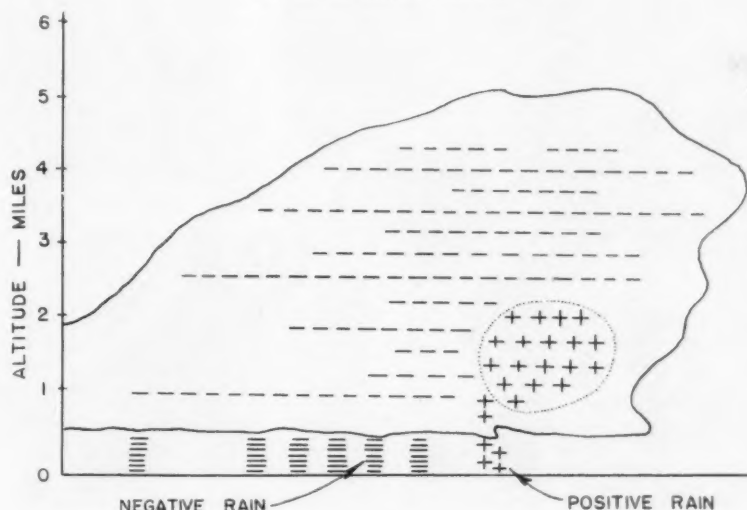




Fig. 3. This lightning stroke to the surface of a lake is accompanied by upward streamers, one of which appears to the left of the base of the stroke.

derclouds; this investigation showed a region of positive charge such as Simpson's. For the remainder of the cloud's bulk the lower areas were found to be negative and the upper areas positive. This agrees fairly well, as do Elster and Geitel, with the observed fact that ninety percent of the lightning strokes to transmission lines are from sources of negative charge.

Ice Crystals Affect Cloud Charging

Simpson further discovered that the temperature in the region of separation of the upper positive and the negative cloud charge is generally below -10°C . Ice crystals, not water drops, must be present and

be involved in a new charge separation process. He had observed earlier that the collision of blown snow and ice results in a separation of charge between ice particles and air. H. R. Beyers thinks that electrification may occur by interaction of water drops and ice crystals, and E. J. Minser found that the majority of the lightning strokes to an airplane flying in a thundercloud were received in regions where the temperature was within a few degrees of freezing. This temperature condition is not accepted by the theory of W. J. Humphreys that charge separation takes place by breaking drops above the vertical center of the cloud, negative charge being carried by cooling air currents down its sides.

A simplification was used here in that the example cloud of Fig. 2 was given only one charge center, the positive one near its head. The usual thundercloud has many more turbulent air currents, and hence develops more than one charge center. The effect of this situation will be seen later.

Field Intensity Triggers Strokes

The possible cloud charging processes which have been presented here appear to be perpetual — as long as the rapid air currents are present to drive the electrification a charge would seem to continue building up indefinitely to a greater magnitude. Of course this does not

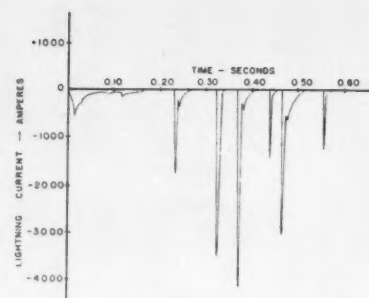


Fig. 4. Reproduction of an oscillogram taken at the Empire State Building of Stroke #13, Aug. 11, 1937. (See also Fig. 6)

happen; the end of the process is the lightning stroke.

When charge builds up in the bottom of a cloud, a charge of opposite sign builds up by induction on the earth beneath the cloud, and an electric field is created between cloud and ground. The intensity of the field is not equal at all altitudes, but is likely to be higher near a charge center in the cloud. When the intensity at some point exceeds the breakdown voltage of air a discharge starts which is similar to flashover, and the lightning stroke has begun.

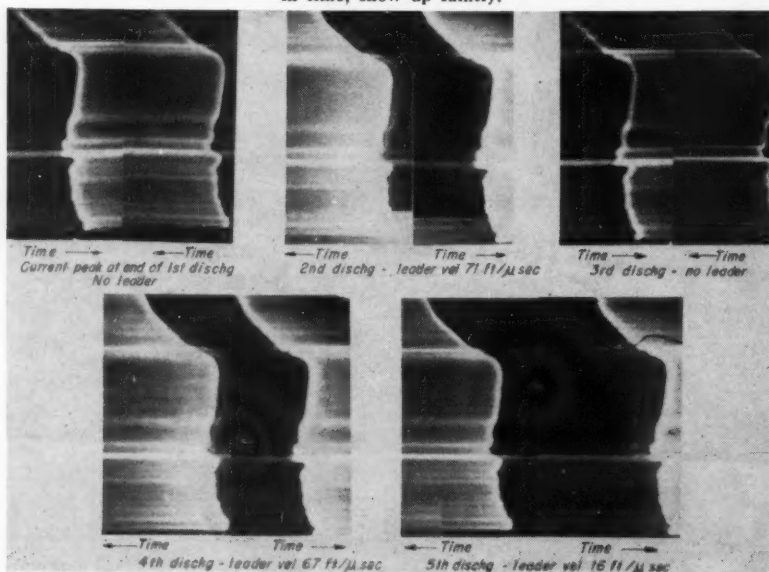
The lightning stroke mechanism is almost completely understood today, but a few points of vagueness will be noted.

Every lightning bolt consists of at least two stages, assuming that it starts in the cloud; these are a downward leader and a faster upward return stroke. The leader is characterized by low current and brightness, and so it rarely shows up in photographs. The return stroke carries most of the charge, so it is known by heavy currents and the brilliant flashes one sees during thunderstorms.

It is now believed that when previously non-conducting air breaks down to start a stroke, a third stage is involved — two leaders are thought to descend. The first one, which, if it exists, has not had its presence recorded in any way, is called a pilot leader and moves continuously downward. The second one is known to exist and has been photographed. It is known as a stepped leader because its downward motion is in rapid steps which are separated by short pauses, its average velocity being the same of that of the theorized pilot leader.

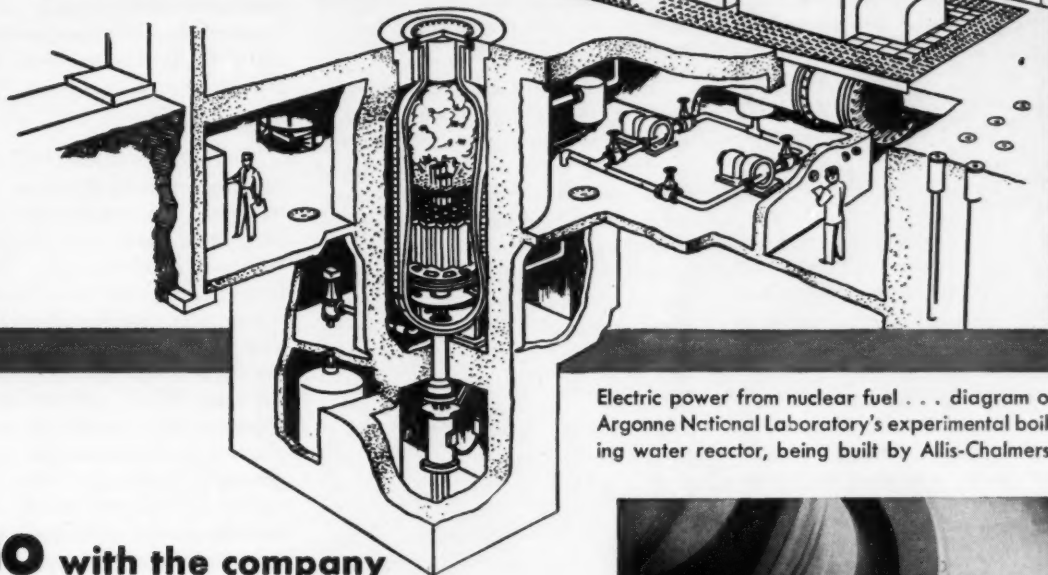
As long as the charge center can
(Continued on page 52)

Fig. 5. High speed Boys Camera photographs of Stroke No. 26, Aug. 12, 1937, which has five components. Two of the leaders were too dim to appear on the film in two cases, but the others, having the same shape as the return strokes and preceding them in time, show up faintly.



POWER...

one of 3 great
growth Industries



Electric power from nuclear fuel . . . diagram of Argonne National Laboratory's experimental boiling water reactor, being built by Allis-Chalmers.

GO with the company that's strong in all three!

Hitch your future in engineering to the growth of the U. S. A.—and to a company that supplies the basic needs of growth!

This nation is growing at the rate of 50,000 people every week! To supply the needs of these people:

Electric power generation will double by 1965.

A multi-billion dollar program of new highway construction is planned within the next ten years.

Manufacturing output will have to increase by \$3.5 billion by this time next year.

And Allis-Chalmers builds major equipment for all of these growth industries! Some examples are pictured here.

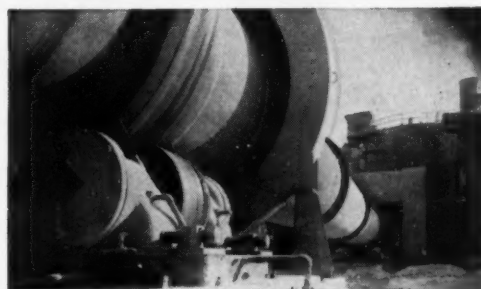
Here's what Allis-Chalmers offers to Young Engineers:

A graduate training course that has been a model for industry since 1904. You have access to many fields of engineering: electric power, hydraulics, atomic energy, ore processing.

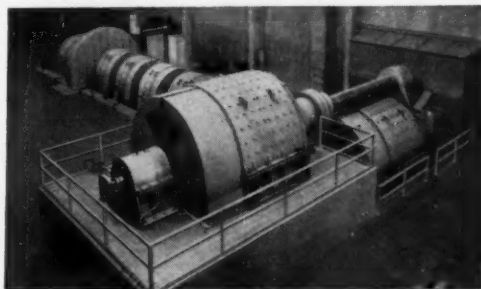
There are many kinds of work to try: design engineering, application, research, manufacturing, sales. Over 90 training stations are available, with expert guidance when you want it. Your future is as big as your ability can make it.

Or, if you have decided your field of interest and are well qualified, opportunities exist for direct assignments on our engineering staff.

In any case—learn more about Allis-Chalmers. Ask the A-C manager in your territory, or write direct to Allis-Chalmers, Graduate Training Section, Milwaukee 1, Wisconsin.



CONSTRUCTION demands the vast tonnages of cement produced with Allis-Chalmers rotary kilns and other processing machinery.



MANUFACTURING depends upon the reliable power of electric motors—like these 5000 hp Allis-Chalmers giants powering a rolling mill.

ALLIS-CHALMERS



A-4683

Steelmaking Processes

by JOHN M. WALSH, ChemE '59

The United States today produces more iron and steel than all the other countries in the world put together. This is due largely to the fact that the United States has been most singularly blessed in having in ample quantities of excellent quality the three principal ingredients required for steel making. These are iron ore, coking coal, and limestone.

Coal Mining

In modern mining practice the coal is divided into huge blocks by machine cutting and then blasted loose. It is then loaded directly by machine onto a conveyor belt which takes it to the cleaning plant. From here it goes by either railroad cars or boats to the coke ovens located at the steel mills.

The coking process in which the coal is changed into coke is mainly a process of distillation. The coal is put into ovens thirty-five to forty feet long, eight to twelve feet high, and sixteen to twenty inches wide where it is heated from seventeen to nineteen hours at a temperature of 2,000 degrees Fahrenheit. When the volatile gases are driven off, the coke which remains is pushed out

of the oven into hot cars. These cars take it red-hot to the quenching station where it is cooled with water. The coke is then ready for use and goes to the blast furnace storage bins where it is stored until needed.

One of the most important operations in the coking process is the recovery of gases driven off during the heating process. In earlier days these gases were allowed to escape into the air. Today these gases furnish fuel for the entire steel plant besides being an important source of several organic and inorganic compounds. These coal chemicals are used to make nylon, fertilizer, drugs, plastics, dyes, explosives and a multitude of other products.

Iron Ores

The major iron ore mines of the United States are of the open pit type. In open pit mining the ore is loaded by huge shovels, which take up to fourteen tons in one bite, into railroad cars or trucks. It is then transported by either rail or water to the stockpiles at the steel mills.

Limestone

The third important raw material for steel making is limestone, which is used as a flux to remove impurities from the iron. It is either quarried or mined underground with methods similar to those used in coal mining.

Blast Furnace

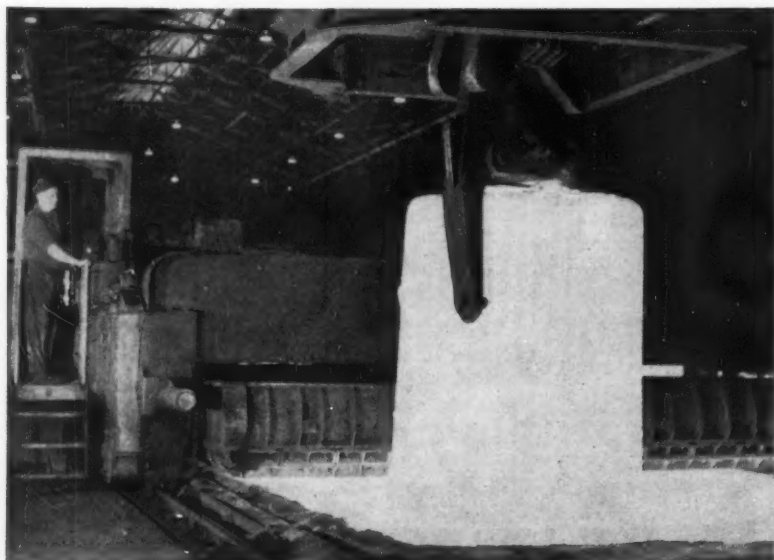
The modern blast furnace is a tall chimney-like structure ranging in height to one-hundred twenty feet. It is narrow at the top but widens close to the base. The blast furnace runs continuously, shutting down only for necessary repairs. This necessitates charging it with ore, limestone, and coke every few minutes. When a blast furnace is charged, the needed raw materials are carefully measured out and placed in a skip car. The skip car travels to the top of the furnace and dumps in the charge. Approximately three and one-half tons of air, preheated to around 1,200 degrees Fahrenheit, per ton of iron is blown into the furnace through water-cooled openings located radially about the bottom of the furnace and called tuyeres.

This air causes the coke to burn fiercely. The burning coke combines with the oxygen of the air to form carbon monoxide. The highly reducing carbon monoxide rises toward the top of the furnace and removes the bulk of the oxygen from the iron ore in the charge. As the charge falls toward the bottom and the hottest part of the furnace, the iron oxide is reduced to molten iron drops which collect at the bottom of the furnace to form a pool of liquid iron three or four feet deep. At the same time the limestone is purifying the charge by combining with unwanted elements in the ore, mainly silica and alumina. This residue of molten waste forms the slag.

Periodically, the liquid iron and slag are drawn off the bottom of the furnace, separated by gravity, and run through separate troughs into their respective ladles. The molten iron is taken to the steel

A reheated, white hot ingot, ready for rolling.

—U. S. Steel



making department of the mill or poured into molds to make pig iron for future use. The slag is either wasted or processed for various uses, such as roadbuilding materials, insulating materials, aggregates, etc.

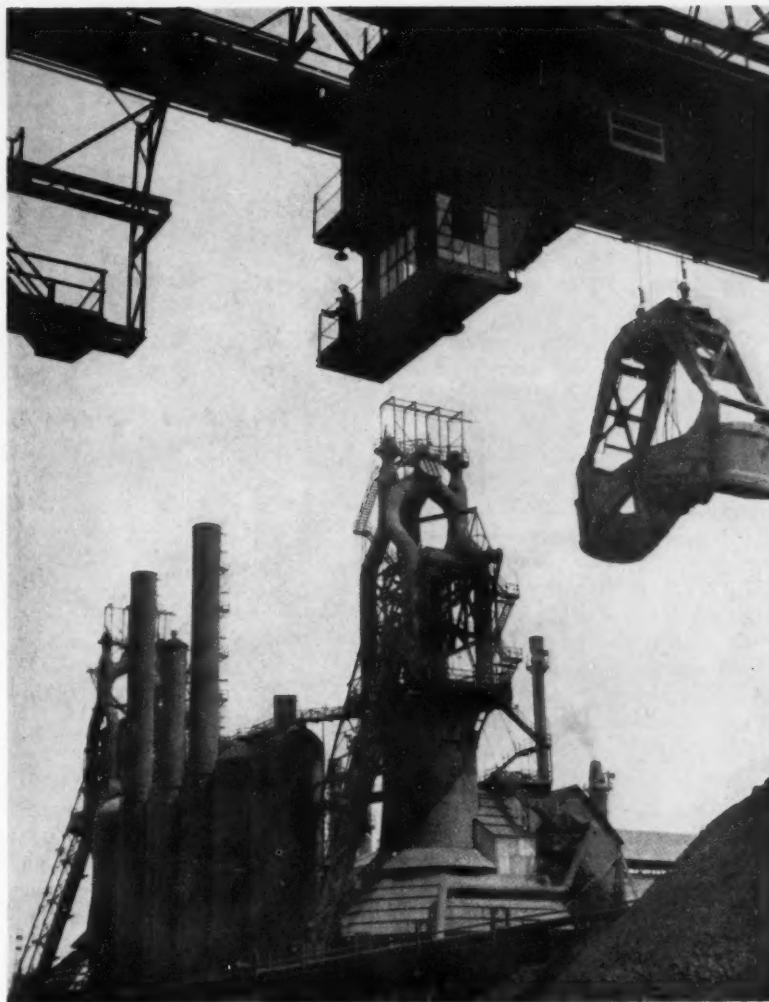
When the iron is cast from the blast furnace, it contains impurities such as silicon, phosphorus, sulfur, and as much as four per cent carbon. A large part of these impurities must be removed. The two principal methods in use today are the Bessemer and open hearth processes.

Bessemer Process

The periodic glow that appears over some steel plants is caused by the working of the Bessemer converter. In the Bessemer process molten iron is poured into the cylindrical shaped converter while it is lying on its side. A blast of air is turned into the vessel through tuyeres which form its bottom; at the same time the vessel is turned upright. The oxygen in the air unites with the silicon, manganese, phosphorus, and carbon in the liquid iron in this sequence. These impurities either go off in the form of a gas or rise to the top as a slag. After twelve to fifteen minutes, when the air has burned out all the impurities, elements are added to the molten metal to give it the required composition. It is then poured into a ladle and in turn teemed into ingots.

Open Hearth Process

However, by far, the major portion of today's steel is made by the open hearth process. The open hearth is a long rectangular brick structure which has a large dish-shaped compartment inside for holding the molten metal. This compartment is partially charged with limestone, iron ore, and steel scrap. At each end of the open hearth is a burner supplying coke oven gas, natural gas, tar or fuel oil to supply the heat. The air for burning this fuel is preheated in checkers and then entered through the burners. This fuel and preheated air mixture, when ignited, causes extremely high temperatures. After about two hours, the steel scrap is melted, and an amount of molten pig iron approximately equal in weight to the scrap charge is added



A modern blast furnace, where initial steel-making operations begin by smelting iron ore into molten iron.

—U. S. Steel

to the furnace. The oxygen in the ore combines with and removes the carbon, silicon, manganese, and phosphorus. The lime combines with these oxidized impurities and the silica in the ore to form the slag. After eight to twelve hours, the open hearth is tapped into a ladle, additions are made and the steel is teemed into ingots.

Electric Furnace

Although the chemical composition of the steel made by the electric furnace can be controlled more exactly, the method is more expensive than the open hearth and Bessemer methods. For this reason only highest quality steels—stainless steel, heat resistant steel, and tool steels—are made in the electric furnace. The electric furnace has a huge dome-shaped roof with three carbon electrodes protruding into

the inside. The carbon electrodes carry the current used to heat the steel and are each capable of being raised and lowered separately. Generally, the electric furnace is charged with cold materials in a method similar to open hearth charging.

When the electricity is turned on, the terrifically high heat given off by the electrodes melts the raw materials. When the first layer of slag forms on top of the molten metal, it is scraped off with raddles. The rake-shaped raddles are made of wood so they will not change the composition of the steel when they burn. The first slag scraped off contains the impurities: phosphorus, manganese, silicon, and carbon. After the first slag is removed, a second slag is formed and is removed. It contains sulfur and other elements. At this point special

metals are added to form alloys. After four to twelve hours, the furnace is tapped into ladles and teemed into ingots.

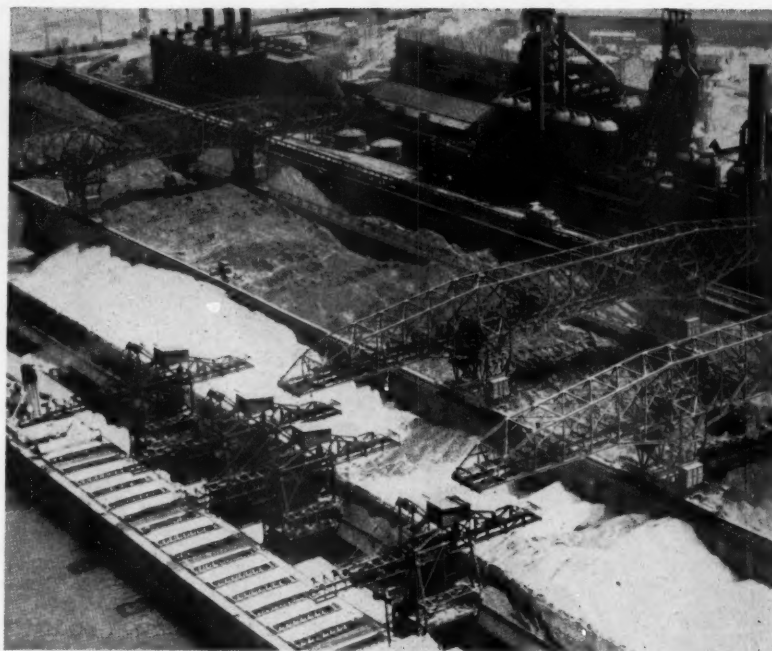
Rolling Mills

The steel ingots are heated uniformly throughout to a temperature of 2200 degrees Fahrenheit in the soaking pits and then moved to the semifinishing mills where the steel is rolled into blooms, billets, and slabs. The major portion of all of these are reheated before rerolling. Blooms and billets are rolled into such finished shapes as rails, structural shapes, rounds, concrete bars, etc. Slabs are rolled primarily into plates or sheet and strip steel of which a large portion are used in the automotive and canning industries. Much of this steel is coated with zinc or tin either electrolytically or by the hot dip method. The rounds may be pierced to form seamless tubing or may be rolled down to smaller sizes and then drawn through dies to form wire. Narrow strip may be curled up at the sides to form a pipe by welding the adjacent edges together.

There are two other methods of shaping steel—forging and casting. In forging the steel is pressed into the desired shape. This is the method used for making railroad wheels. Casting is forming steel by pouring molten steel into a form and letting the steel harden into the desired shape. Casting is especially important in the manufacture of heavy machinery.

Linz-Donawitz Process

The newly developed Linz-Donawitz process appears to have great possibilities. In this process oxygen is blown under very carefully regulated conditions through a water-cooled tube onto the top of a bath of molten pig iron. The vessel used is very much like the Bessemer converter except it has a closed bottom. The oxygen combines with the impurities in the molten pig iron oxidizing them either to a gas or to a slag. The advantage of the process is that no nitrogen is introduced into the steel as in the Bessemer process. One of the disadvantages is the heavy brown fumes caused by the volatilization of the iron and the corresponding heavy iron loss.



Ore boat unloading at dock beside raw materials storage yard.

—U. S. Steel

Direct Casting

There have been many attempts over the years to cast steel directly from pouring ladles into continuous shapes such as slabs, blooms, and billets, thus eliminating the primary rolling mills. This is being accomplished today at several places both in Europe and in this country. Molten steel is poured from the ladle into a tundish, a type of funnel, and then dropped into a vertical water-cooled copper mold where it is shaped into a slab or billet. The mold oscillates vertically to keep the solidifying steel from sticking as it drops downward. As the solidifying section comes out of the bottom of the mold, the steel is given a quick final processing in three steps: tubes spray a coolant to lower the temperature of the red-hot steel; pinch rolls press against the steel and give it a downward tug; a moving torch moves across the steel to cut it into sections. The individual slabs drop into a metal basket that turns them down onto an outward bound conveyor.

Taconites

The great Mesabi Range is fast becoming depleted. To replace this source of iron ore the steel industry is turning to lower grade iron bearing materials called taconites. These are iron oxides mixed with silica

in very small grain sizes. These taconites must be beneficiated to a much higher iron content and a much lower silica content before smelting. The present primary concentration process is to crush these iron bearing rocks in huge gyratory crushers followed by cone crushers to a size where they can be handled in a rod mill. This mill crushes them to a point where they can be handled by a ball mill which further crushes them to approximately 200 mesh. The iron bearing materials are then separated from the tailings either by magnetic or flotation processes or combinations of these two. The resultant concentrates contain approximately 60% Fe but being of the magnitude of 200 mesh they are entirely too fine to be smelted in a blast furnace. They must be agglomerated. There are three major agglomerating processes undergoing elaborate experimentation at the present.

Nodulizing

One is nodulizing. Here the concentrates are fed into a 350 foot rotary kiln, rolled up and fused into metallic balls approximately one half inch in diameter.

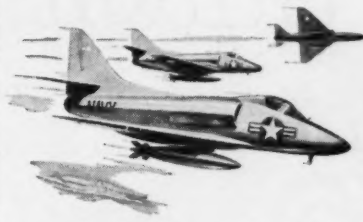
Sintering

In sintering the concentrates are

(Continued on page 52)



F4D, "SKYRAY"—only carrier plane to hold official world's speed record



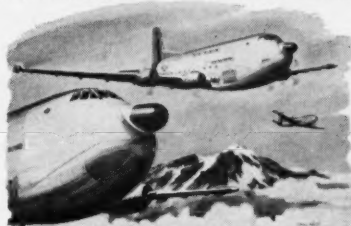
A4D, "SKYHAWK"—smallest, lightest atom-bomb carrier



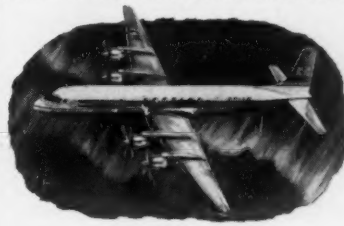
RB-66—speedy, versatile jet bomber



A3D, "SKYWARRIOR"—largest carrier-based bomber

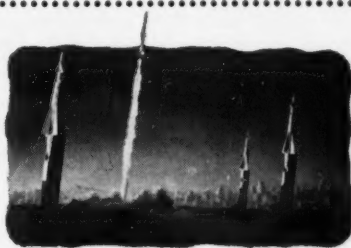


C-124, "GLOBEMASTER"—world's largest production transport

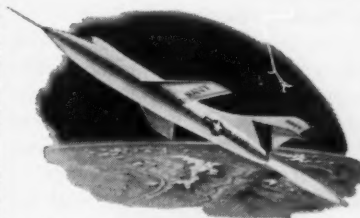


DC-7 "SEVEN SEAS"—America's finest, fastest airliner

Engineers: join this winning team!



"NIKE"—supersonic missile selected to protect our cities



D558-2, "SKYROCKET"—first airplane to fly twice the speed of sound

At DOUGLAS you'll be joining a company in which the three top executive officers are engineers...you'll be associated with men who have designed the key airplanes and missiles on the American scene today! Nothing increases an engineer's ability faster than working with other engineers of top calibre.

Not only is Douglas the largest manufacturer of commercial aircraft in the world, but it also produces outstanding aircraft and missiles for *every* branch of the armed services! This diversity, besides giving you job security, provides unequalled opportunity for the engineer with an eye to the future.

Challenging opportunities now exist in the following fields:

- Mechanical design**
- Structural design**
- Power plant installation design**
- Weapons delivery**
- Aerodynamics**
- Thermodynamics**
- Electronic computers**
- Systems analysis**
- Aircraft air conditioning**
- Hydraulics**
- Stress analysis**
- Servo mechanisms**
- Acoustics**
- Electronics**
- Mechanical test**
- Structural test**
- Flight test**
- Process engineering**
- Missiles**



Brochures and employment applications are available at your college placement office.

For further information relative to employment opportunities at the Santa Monica, El Segundo and Long Beach, California divisions and the Tulsa, Oklahoma division, write today to:

DOUGLAS AIRCRAFT COMPANY, INC.

C. C. LaVene, Employment Manager... Engineering General Office
3000 Ocean Park Blvd... Santa Monica, California

CYCLONITE

Known to the Military as "RDX", this compound has explosive properties of great interest to organic chemists

by C. V. CHESTER, Chem E '56

Ever since some person or persons unknown discovered the art of producing black powder, men have searched for better mixtures and compounds which could rapidly release quantities of stored chemical energy, under the proper stimuli. The Nineteenth Century was most notable for the successes in this quest—virtually every explosive compound known today was first synthesized after 1840 and before 1900.

Is There a "Best" Explosive?

The question is often asked, "What is the 'best' explosive?" The response to this is, "What does one mean by 'best'?" A good explosive should be powerful, cheap, physically and chemically stable, non-toxic, insensitive enough to use, and yet easily initiated. Perhaps the most powerful explosive is a stoichiometrically balanced mixture of tetranitromethane and toluene. But this stuff is dangerously sensitive to initiation, and also is rather volatile. Ammonium nitrate is one of the cheapest explosives known, but it is weak, hard to detonate, and readily takes up moisture from the air to become unexplodable. Nitroglycerin is powerful and cheap, but is too sensitive and chemically unstable, even in dynamite, for many applications. Trinitrotoluene, or TNT, has very nearly ideal chemical and physical properties, but is not as powerful or economical as one might like.

The explosive compound generally conceded to have the "best" combination of desirable properties was not well known, and, in fact, did not see other than experimental use prior to the second World War. But it was first synthesized in the last century.

In 1899 a German chemist by the name of Henning patented a white insoluble product of the nitration of the nitrate of hexamethylene tetramine. Ignorant of its explosive nature, he thought his

compound might have medicinal properties. It is ironic that, to date, the largest-scale use of Henning's "medicine" has been to shatter cities of his native Germany, in British and American blockbusters.

Hertz, working in the United States, discovered and patented, in 1920, the use of the compound as an explosive. This compound is now known in the United States and Britain as "Cyclonite," from its cyclic structure and powerful blast effect. During the last war, the code name RDX was applied by the British, but this name has come to refer to certain commercial and military mixtures containing the compound. The Germans and Italians used Hexogen and T-4, respectively, to denote the explosive.

Physically, cyclonite in the pure state is usually a rather fine white powder, which under the microscope appears as colorless orthorhombic crystals. The crystals have a specific gravity of 1.816, melt at

204.1° C. and dissolve readily in acetone, warm concentrated nitric acid, hot aniline, and phenol. They are almost insoluble in water and a number of organic solvents.

What is of interest about this material is that, pound for pound, it is the most powerful explosive of the chemical compounds known to man. Its blast effect is one and one-half times that of TNT. It is about ten percent more powerful in this respect than pure nitroglycerin. It is exceeded in *brisanse*, that is, sharpness or shattering ability, by only dinitroglycol and erithritol tetranitrate, and then only slightly.

Tests Indicate Explosive Qualities

Power of an explosive usually refers to its heaving ability: how much dirt, rock, and rubble can be lifted by a charge. A fairly good, i.e. reproducible, measure of this quantity may be obtained by observing the momentum given a ballistic pendulum by the detonation of a specified amount of the explosive. Comparison of the powers



Components for the detonation test of an RDX explosive. From top to bottom; a 20 gram, one inch by one inch paper-wrapped cylinder of RDX Composition C-3, an electric detonator, and a 4 inch by 4 inch piece of 1/4 inch 1020 steel plate.

of explosives in a semi-quantitative manner is usually made from ballistic pendulum data, often using TNT as a standard.

Brisance is usually tested by detonating a small quantity of the explosive in a strong container filled with a carefully sieved quartz sand. The weight of sand crushed such that it will pass the next smaller sieve is a standard measure of this quality.

Sensitivity, or lack thereof, of an explosive is indicated by the height from which a given weight must be dropped to explode a sample on an anvil a given fraction of the try—often ten percent. On this basis cyclonite has a ten percent success drop height using a two-kilogram weight, of 18 centimeters, as compared with 15 for nitroglycerin and 100 for TNT.

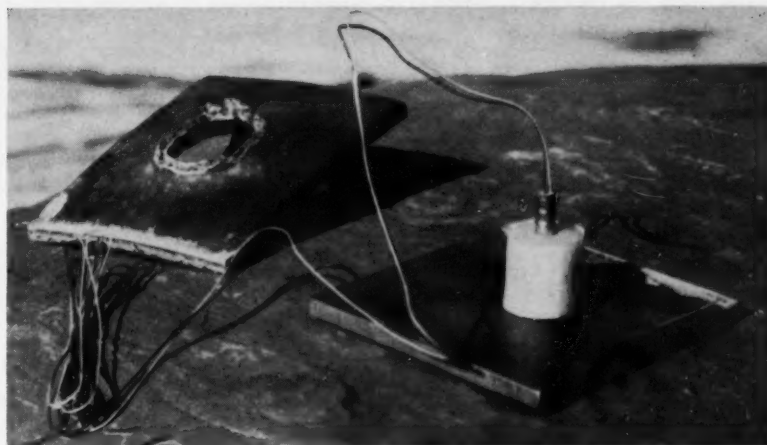
From these figures, pure cyclonite is much too sensitive for military use. This is the case, and pure cyclonite is not used as such. Fortunately the explosive is very easily phlegmatized; that is, made much less sensitive by mixing with it a small amount of some substance such as wax, castor oil, or some resin. The power of the explosive is not appreciably reduced by this process.

The Manufacture of Cyclonite

Chemically, cyclonite is known as cyclo trimethylene trinitramine, or 1, 3, 5-trinitro hexahydro-s-triazine. (The latter more esoteric name is preferred by organic chemists who like to impress the ignorant engineers.) The essential steps in the preparation are shown in figure 1.

An aqueous solution of formaldehyde and ammonia is evaporated to dryness, and the residue, a crystalline white solid, is urotropin, or hexamethylene tetramine. This substance becomes cyclonite when dissolved in a large excess of 98% nitric acid, and the ensuing solution is drowned.

The dependence of the process on formaldehyde and ammonia precluded much interest in cyclonite as a military explosive before 1920. Formaldehyde is made from wood alcohol, or methanol, and prior to this date, the sole source of methanol was the distillation of wood—a rather expensive process. Ammonia, also, at this time was pro-



Test components assembled, and result. The test assembly, shown here on rock, is actually fired on soft sand, by connecting a dry cell to the detonator wires. The fired test plate to the upper left shows the neat hole cut by the explosive. The bottom of the plate is shown. Note how the plate is bent slightly, indicating how sharp, or brisant the explosion was.

cured from natural sources and was not cheap.

However, before and after the First World War, experimental work in France and Germany was going on, aiming at the synthesis of methanol and other organic compounds by the catalyzed reaction of hydrogen and carbon monoxide under pressure. This work culminated in the production of methanol on a commercial scale in 1923 by the Bzdisch Anilin- und Soda- Fabrik. Production of synthetic ammonia from nitrogen and hydrogen was developed at the same time, using an identical process and equipment.

With nitric acid produced from the oxidation of ammonia, it became possible to produce an explosive from no other materials than coke, water, and air. This attracted interest in Europe, which suffered an oil and fat shortage. However, it is a long hard way from the test tube to the pilot plant, and then to commercial production.

British Pioneer Large Scale Production

About 1922, the British, who were the most successful in the large-scale production of the explosive, began investigating the synthesis of cyclonite at Woolwich Arsenal. The original batch method developed by von Hertz was dangerous, for many unstable and sensitive by-products were produced by side reactions. After much painstaking work, interspersed with an occasional rather spectacular reaction, these by-products were iden-

tified, and some of their properties determined. A method was developed consisting of continuous nitration followed by a hot dilution, which safely decomposed the unstable products. In this process, hexamine is added continuously to a large excess of 98 percent nitric acid kept at room temperature. The mixture is then diluted with water at 70° to 80° C. precipitating stable granular cyclonite, which is then purified, phlegmatized, and packed.

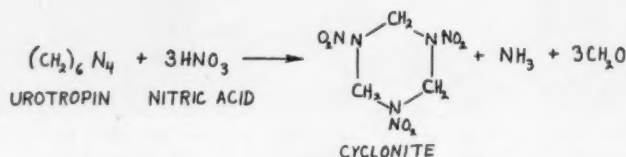
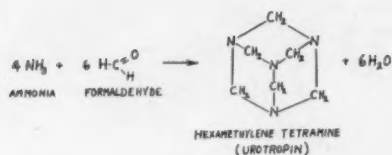
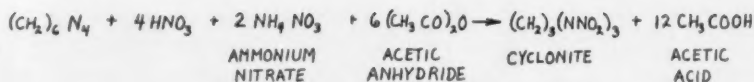
In 1933 the process at Woolwich went on stream producing 75 pounds of explosive per hour, without recovering the acid in the dilution. This was the first trouble-free, commercial-scale production of cyclonite in the world.

Over 11 tons of nitric acid were consumed in the production of one ton of cyclonite by this process. Of this, approximately 5½ tons can be recovered by absorption of the quantities of nitrous fumes evolved in the nitration and dilution. The problems of fume absorption and acid concentration on this scale were relatively new to the British Chemical engineers on the project, but they did a very competent job, and by 1939 acid recovery was in operation at Woolwich.

In 1941 a full scale plant near Bridgewater, England, was completed and produced its first RDX. Initial capacity was 90 tons per week, and was later increased to 180.

Process Has Expense Drawback

This process, while producing a



good grade of explosive, suffers from several disadvantages. The large excess of 98 percent nitric acid necessitated by fume-off and production of water in side reactions, is expensive, and unreacted acid is diluted at the end of the process. This involves reconcentration and purification of relatively huge amounts of nitric acid (by distillation with sulfuric acid) for any sizeable production rate, and requires an elaborate and expensive plant. In addition, and perhaps the major objection to the process, the destructive nitration of one mole of urotropin produces at least three moles of formaldehyde, which is largely oxidized by the nitric acid, and wasted. One mole of ammonia is also released, but this is largely recovered. Now while formaldehyde from synthetic methanol is cheaper than that from natural methanol, it is by no means free. And even if it were completely recovered in the process, one would have to go to all the fuss and bother of putting it back into urotropin molecules.

A New Approach:

The Bachmann Synthesis

Two chemists at the University of Michigan, Doctors W. E. Bachmann and John C. Sheehan, tackled this problem. Their approach was this: if somehow more ammonia and nitric acid can be brought into the process as reactants, maybe the nitration equation can be balanced up, producing nothing except cyclonite and water. Eventually the reaction in figure 2 was evolved. The additional ammonia was added as the very cheap nitrate, supplying some of the NO_2 radical and re-

ducing the demand for nitric acid. At the cost of one more mole of nitric acid, and two moles of ammonium nitrate, the theoretical yield of the reaction can be doubled, a very profitable arrangement.

While the reaction looks nice on paper, it has a couple of jokers in it. One is the water produced. This would dilute the reaction mixture, cause side reactions, and cut down the yield. In more conventional nitrations, such as those of benzene, toluene, glycerin, etc., the water produced is removed by having some sulfuric acid present to take it up by hydration. (The sulfuric acid also helps catalyze the reaction, but is not essential for this purpose.) Unfortunately cyclonite is decomposed by sulfuric acid, so this way out of the problem is denied.

By having a large excess of nitric acid present, the bad effects of the water could be attenuated, but aside from bringing back the reconcentration problem, the second difficulty would be encountered: the oxidation of the nascent formaldehyde. Hot concentrated nitric acid is a patent oxidizing agent, and while formaldehyde is more resistant to oxidation than other aldehydes, it cannot long survive these conditions. To circumvent both of these difficulties at once, the ingenious scheme was devised of using acetic anhydride as the reaction medium or solvent. One mole of this chemical will react with one mole of water to form two moles of acetic acid. In addition, this anhydride is not an oxidizing agent.

"Bugs" In the Reaction

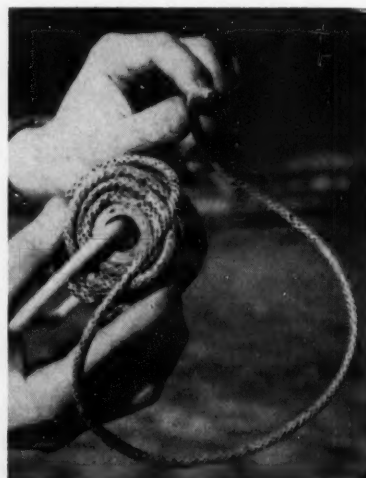
After the basic reaction was de-

vised, it was then necessary to get it to work. This involved finding proper temperatures, concentrations of reactants, rate and order of addition of reactants, and other details that plague the chemist. A series of gunks, goos, and spectacular fume-offs were produced until they were determined. It was found, among other things, that it is necessary to add the reactants (HNO_3 , NH_4NO_3 , and $(CH_2)_6N_4$) in small equimolar quantities to the hot acetic anhydride. The temperature must be maintained above $50^\circ C$ to decompose a by-product, known later as BSX. The reaction temperature finally arrived at was about $70^\circ C$.

In addition, another by-product, HMX (for "High Melting"), was discovered. This compound is very similar to cyclonite, having an eight-membered ring of four nitramine groups and four methylene groups. The name is cyclotetramethylene - tetraaminamine. Four isomers of this compound are produced. Only one, the keto isomer, is stable. Removal of the unstable isomers presented additional complications in the purification of the product.

Three-liquid Synthesis Suggested

As an example of laboratory preparation of cyclonite, the following three-liquid synthesis is suggested in a United States patent (U. S. 2,434,879):



A roll of "Primacord." Resembling rope, this is really a plastic and fiber tube filled with a cyclonite-type explosive. Rather than burning like conventional fuse, it detonates at about four miles per second. It is used for the almost instantaneous transmission of an explosion from one point to another.

Three solutions are prepared:

- (1) 0.24 moles of urotropin in 160 ml. glacial acetic acid.
- (2) 0.48 moles dry ammonium nitrate in 11 moles of commercial 97% nitric acid.
- (3) 1.7 moles of acetic anhydride.

The acetic anhydride is heated to 60° C in a suitable reaction vessel. The nitrate and urotropin solutions are each preheated to 40° C. and added a small proportional quantities, the reaction mixture being well agitated and maintained between 70 and 75°C. After all the reactants have been added, the mixture is allowed to react for 15 or 20 minutes, and then 640 ml. of water at 40° C. is added slowly. The solution is then cooled to 2° C, held there for four hours, and the product filtered off. The yield should be about seventy to eighty percent of theoretical. The product can be purified by recrystallization from acetone or 70% nitric acid, and should be stored under water.

New Method Poses Operational Problems

To get from the test tube stage to commercial production by the new method, the aid of organic chemists of many colleges and universities was enlisted, including that of Doctor Blomquist of Cornell. After more experimentation, a process similar to the one described above, using only liquid feeds, was developed. The process as used in operation by the Tennessee Eastman Company, involved the continuous mixing of the liquid feeds in a large reactor with provisions for agitation and continuous removal of the resulting cyclonite-acetic acid slurry. Prior to 1949, a cyclonite production rate of 360 tons per day had been achieved.

However this process also had its drawbacks. As a result of the milder reaction conditions and more complex reaction mixture, greater quantities of unstable by-products are separated with the cyclonite. To stabilize the product, an elaborate system of recrystallization from acetone must be used.

The big expense is the consumption of acetic anhydride. It cannot be easily made from only acetic acid. Tennessee Eastman produces it from Ketene, an unsaturated



An example of RDX and Primacord being used simultaneously. The shaped charges being strung on the Primacord will be used to perforate an oil well casing. The cord serves to carry the detonation from the top of a carrier to the bottom and initiates the charges as it passes by them.

compound which can be made from acetone, and acetic acid. Much work has been done on the recovery of acetic acid from the reaction mixture, as one way of reducing the cost of the process.

The problems of production of acetic anhydride and recovery of acetic acid in the Bachmann process are analogous to those of nitric acid production and fume recovery in the nitric acid process. The Bachmann method usually produces a less pure reaction product, but is somewhat easier to control and safer to operate. Opinion as to which is the better process is divided.

RDX Ideal For Military Use

RDX explosives are the joy of ordinance officers; usually having about 1.3 times the power of TNT. At the beginning of World War Two, Britain was short of aircraft. However, three planes loaded with RDX could carry the destructive power of four loaded with TNT. The comfort this gave the RAF bomber squadrons is obvious. Similarly a frogman, or miner and sapper, can carry the equivalent of 80 pounds of TNT by carrying 60 pounds of RDX.

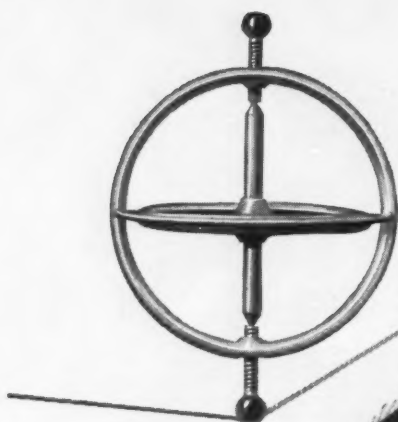
Being powerful, chemically very stable, easily phlegmatized, and

solid, cyclonite has the pre-requisites of an almost ideal military explosive. Its only serious drawback is its expense, which is greater than that of TNT. However this is not always a primary consideration with the military. Since an infantryman under fire, and a bomber over enemy territory are about the most expensive freight carriers known, the savings in weight more than compensates for the increased cost of the explosive.

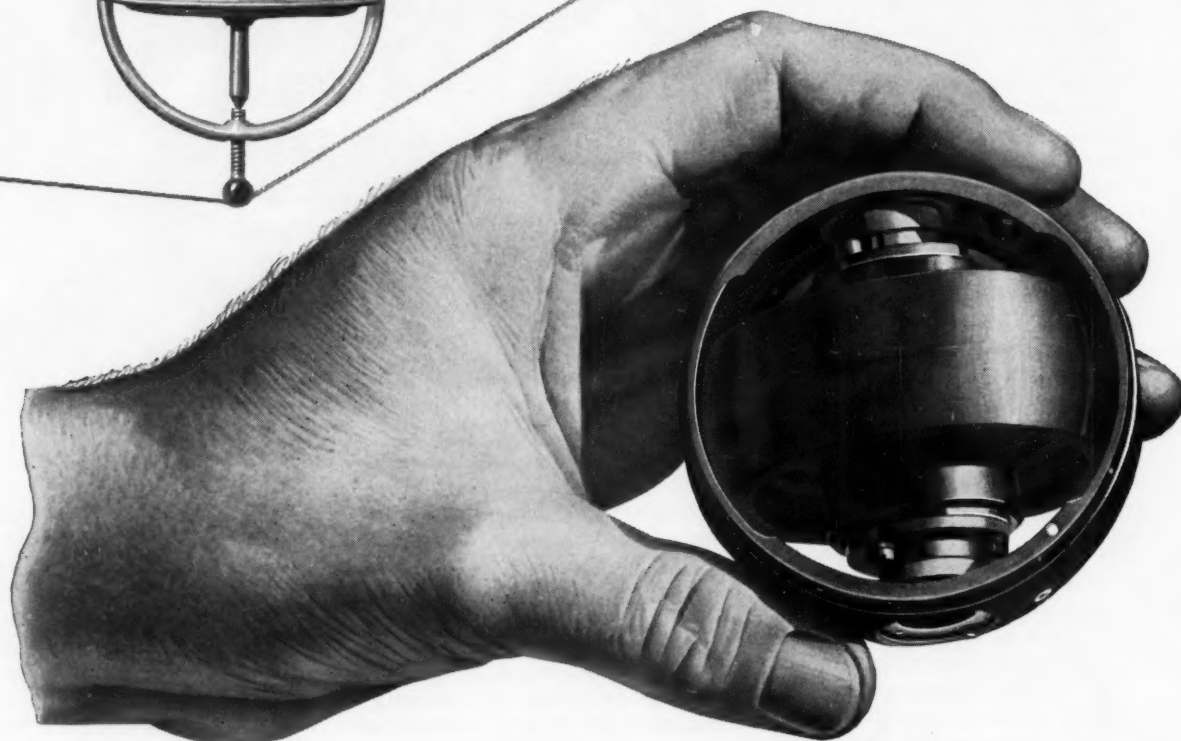
Cyclonite also suffers from the slight disadvantage of a high melting point, melting with decomposition, and hence may not be cast in shells and bombs. It is usually loaded dissolved in molten TNT, or else mixed with some resinous binder and extruded into the desired ammunition components. "Cyclotol" is the name of a melt-loaded mixture of 60 parts cyclonite and 40 parts TNT, used in bombs where great blast and shattering effects are desired. "Torpex" is a similar mixture with the addition of five or ten percent aluminum flake. The aluminum raises the temperature of the explosion, and increases the blast effect.

Cyclonite In Plastic Explosives

The great brisance and power of
(Continued on page 50)



You Remember the Toy...
HERE'S THE REAL M^CCOY!



Bendix GYRO... amazingly precise navigate planes, guide missiles, point

ONE of the first gyroscopes on record is credited to Bohnenberger; the date, 1810. Compared to today's precision-made gyros, of course, it was in the toy class.

The evolution of the gyro from a novelty to a definite place of importance in the field of aviation and our national defense program is worth noting.

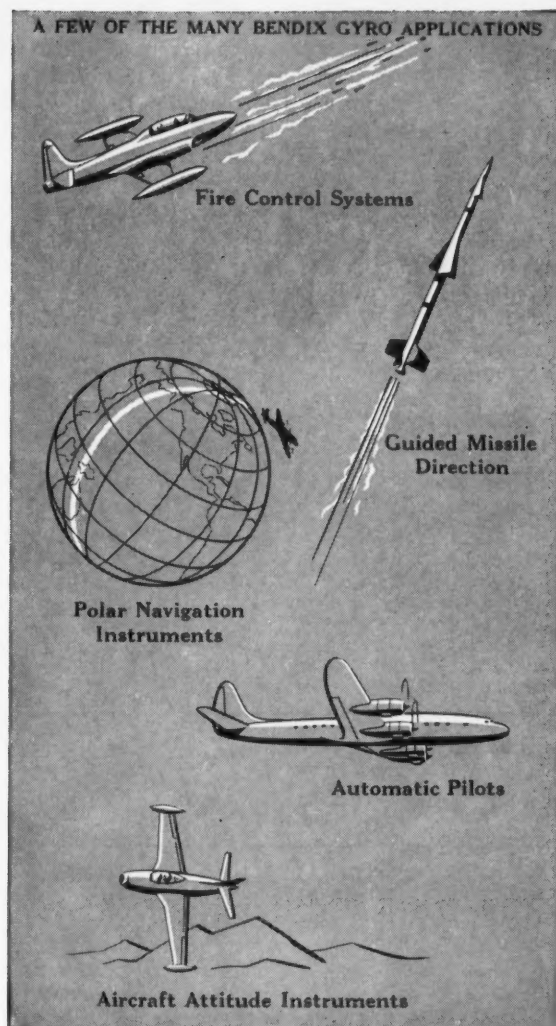
The value of a gyro is in direct ratio to its accuracy. Thus, even if early applications had been apparent, the gyros of the 19th century could not have met the requirements.

Some of the first practical applications of the gyro were in instruments for airplanes. And while most Bendix Gyros today still find their way into commercial and military airplanes, they also do many other jobs—help point guns, stabilize aerial photographic platforms, direct and stabilize radar antennas and many others.

It should be explained that a gyro does not stabilize or control anything directly—*except itself*.

But its peculiar ability to hold *itself* fixed, almost unwaveringly, in any designated position despite the movements of the object to which it is attached, provides the gyro's user with a vital requirement—a firm, stable reference point on which to base calculations or corrective actions.

Developing and manufacturing gyros and gyro-controlled instruments for blind flight, automatic pilots and the famous Bendix Polar Path† compass which has made polar navigation practical, is another facet of the Bendix Aviation Corporation's diverse operation handled by our Eclipse-Pioneer Division, Teterboro, N. J. Contacting E-P will get you quick answers to problems involving aviation instruments and components.



PRINCIPAL DIVISIONS AND BASIC PRODUCTS

ECLIPSE-PIONEER, TETERBORO, N. J.
aviation instruments and components; foundry.

SCINTILLA, SIDNEY, N. Y.
aviation ignition systems; industrial engine magnetos; diesel fuel injection; electrical connectors; ignition analyzers.

RED BANK, EATONTOWN, N. J.
electron tubes; dynamotors; inverters; AC-DC generators.

BENDIX RADIO, TOWSON, MD.
radar; auto, railroad, mobile and aviation radio; television.

ECLIPSE MACHINE, ELMIRA, N. Y.
bicycle coaster brakes, Stromberg carburetors, electric fuel pumps, starter drives.*

ZENITH CARBURETOR, DETROIT, MICH.
automotive, marine and small engine carburetors.

BENDIX-SKINNER, DETROIT, MICH.
micronic filters.

PACIFIC, NORTH HOLLYWOOD, CALIF.
telemetering equipment; hydraulic and electric actuators; depth recorders; boat steerers.

BENDIX FRIEZ, TOWSON, MD.
meteorological instruments, precision instruments and recorders.

BENDIX PRODUCTS, SOUTH BEND, IND.
automotive brakes, carburetors, power steering; aviation brakes, landing gear, fuel metering.

MARSHALL-ECLIPSE, TROY, N. Y.
brake blocks, brake lining, synthetic resins.

CINCINNATI, CINCINNATI, OHIO
automatic viscosity regulators, nuclear products.

BENDIX COMPUTER, LOS ANGELES, CALIF.
digital computers.

HAMILTON, HAMILTON, OHIO
jet engine controls and aircraft pumps.

LAKE SHORE, ST. JOSEPH, MICH.
power steering and automotive devices.

UTICA, UTICA, N. Y.
aviation components.

MONTROSE, SOUTH MONTROSE, PA.
aviation components.

PIONEER-CENTRAL, DAVENPORT, IOWA
aviation instruments and components; ultrasonic cleaners.

YORK, YORK, PA.
electronic devices; test equipment.

BENDIX-ECLIPSE OF CANADA, LTD.
Windsor, Ont.

BENDIX INTERNATIONAL
New York City

*REG. U.S. PAT. OFF.

†EXCLUSIVE TRADE NAME OF BENDIX AVIATION CORPORATION

"tops" that help fly and guns, take pictures, aim radar!

For the complete picture of Bendix and ideas on how some of our thousand products can contribute to the efficiency of your business, write to the address below for the brochure "Bendix and Your Business."

ENGINEERS: Bendix diversity offers unlimited opportunity to experienced men and undergraduates. Write for the interesting brochure "Bendix and Your Future."

BENDIX AVIATION CORPORATION
Fisher Building • Detroit 2, Michigan



Brain Teasers

Last month we left a prominent member of the engineering faculty, along with his two assistants, perched precariously in the libe tower with only a pulley arrangement and a weight standing between themselves and the angry mob below. To get them out of this situation, let P represent the professor (weighing in at 195 lbs.), B represent the 105 lb. assistant, C represented the 90 lb. associate assistant, and W the 75 lb. weight—soon to be tossed around like crazy. Now, to get the boys out of the tower, put W in one basket and let it go. This exceeds the 15 lb. maximum difference, but weights are pretty durable. Next, put C in the other basket. C goes down, W comes up. Now B goes down and C comes up. Drop the weight out of the tower again, then P goes down and B & W comes up. Drop W again, then C goes down and W comes up, followed by

B going down and C coming up. As a final gesture, drop W again, then C goes down and W goes up. All three men having thus been lowered to safety, they can make it to Sibley on their own—to give another prelim another day.

Our second question wanted to know about the legality of a man marrying his widow's sister. To anyone who might have said that such an arrangement would be feasible in most states, we can only answer: "You are dead wrong." A man who has left a widow would be unable to marry anyone, being deceased as he is.

Thirdly, we wanted to know the denominations of two current U.S. coins totaling fifty-five cents—one of which is not a nickle. The answer is that they are a nickle and a fifty cent piece. One is not a nickle, true, but the other is.

To clear up past business, the

winner of the March "Brain Teasers" was an astute old dad, an E.P. from the class of 1956, Donald L. Iglehart.

Thus, with many thanks and apologies to all who have written in with variations of correct answers, we bid adieu until October. See you then.



INDUSTRIES
THAT MAKE
AMERICA GREAT

RUBBER... BOUNCING HIGHER AND HIGHER

Rubber, natural and synthetic, is so elastic in its applications to daily living that millions of people ride on it, walk on it, sit on it, sleep on it—in fact, use it in more than 80,000 different products. 1,498,906 tons were consumed in 1953 alone. This industry's remarkable growth (U.S. consumption of 2,419,700 tons, or 27.7 pounds per person, is forecast for 1960) is largely due to management's wisdom in reinvesting profits in the tools of production and distribution to encourage company growth.

Anyone whose memory goes back 10 years or more can remember the heroic efforts of the rubber companies by which they averted a serious wartime rubber shortage which threatened both military transport, and family transportation. The phenomenal gains made by the rubber industry in the last decade have met civilian demands and have provided an emergency stockpile as well.

And in this history of rubber research, development and



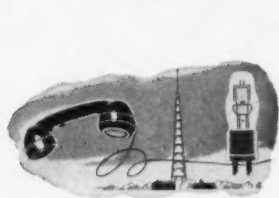
growth, steam has made—and is making—a basic contribution. Without steam and its teammate power, many of the accomplishments of rubber would have been more difficult, impracticable or even impossible to attain.

B&W, through its own vast program of research and development, coupled with boiler building experience dating back almost a century, has made major contributions of its own to the science of steam generation for processing, power and heat—and through them to the modern-day marvels of rubber.

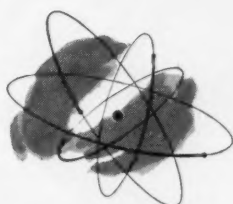


N-200

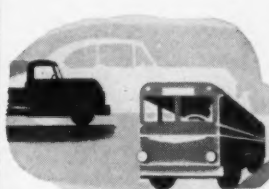
12 of the basic industries in which Bendix products play a vital role



ELECTRONICS



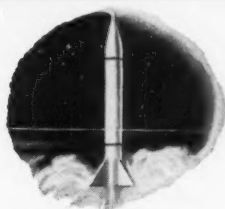
ATOMIC ENERGY



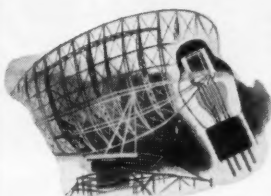
AUTOMOTIVE



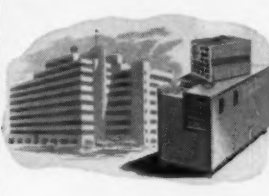
AVIATION



GUIDED MISSILES



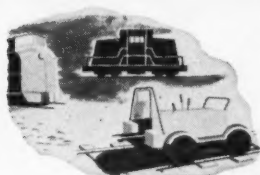
RADAR



COMPUTERS



MARINE



RAILROAD



PETROLEUM



CONSTRUCTION



AGRICULTURE

A SOUND REASON WHY *Bendix* OFFERS TODAY'S ENGINEERING GRADUATE AN UNLIMITED FUTURE!

Diversification is an important asset in business.

Especially so from the viewpoint of the engineer because:

It encourages and promotes freedom of ideas. Keeps engineering ingenuity flexible and adaptable. In short, gives full vent to an engineer's creative ability . . .

While at the same time it provides a healthy, stable, secure foundation for both the company and the individual to build and expand.

If diversification in business appeals to you as a graduate engineer, you'll be greatly interested in the Bendix Aviation Corporation.

For Bendix is unlike any other company in America in its versatility, facilities, experience, range of products and different fields of engineering endeavor. Nearly a

thousand different products are produced by our 24 manufacturing divisions.

As a result, we not only offer a wide choice of locations coast to coast but also career-building opportunities as broad as your ambition and ability in mechanical engineering . . . hydraulic mechanisms . . . electronics . . . magnetics . . . computers . . . servo-mechanisms . . . radar research . . . metallurgy . . . solid-state physics . . . instrumentation . . . radiation detection . . . nuclear physics . . . guidance and control systems plus many more engineering fields of challenge.

Write for your copy of "Bendix and Your Future." It gives the full story about Bendix, its products and employment opportunities.

BENDIX AVIATION CORPORATION

Fisher Building • Detroit 2, Michigan

A Bendix representative will be at your campus soon. Make a note now to talk with him. Check your placement bureau for time and date.





PITTSBURGH PLATE HAS MANY IRONS IN THE FIRE

... maybe you should have a grip on one of them!

Although Pittsburgh Plate Glass Company is the best known name in glass, it is also one of the nation's leading producers of paints and brushes, of alkalies and related chemicals, of plastics and fiber glass.

These multi-industry operations offer the college graduate many and varied types of careers in manufacturing, research, marketing, sales and administration.

PPG's record is one of continual growth throughout its more than 70 year history. Its operations are nation-

wide and in many foreign countries. Progressive policies assure unlimited opportunities for alert men who are looking ahead to more than "just a job."

PPG is seeking good men with college training. If you think you'd like to try your "grip" on one of the many PPG "irons," you're invited to write today for more information. Just address: Pittsburgh Plate Glass Company, General Personnel Director, One Gateway Center, Pittsburgh 22, Pennsylvania.



PAINTS • GLASS • CHEMICALS • BRUSHES • PLASTICS • FIBER GLASS

PITTSBURGH PLATE GLASS COMPANY

319 PLANTS, MERCHANDISING BRANCHES, AND SALES OFFICES LOCATED IN 250 CITIES

YOU FURNISH THE PRINT, WE'LL FURNISH THE PART

MEMO
PROPERTIES OF SYNTHANE USED FOR THIS PART

<input checked="" type="checkbox"/> Tensile Strength	<input type="checkbox"/> Low Dielectric Constant
<input checked="" type="checkbox"/> Compressive Strength	<input type="checkbox"/> Insulation Resistance
<input checked="" type="checkbox"/> Flexural Strength	<input type="checkbox"/> Arc Resistance
<input type="checkbox"/> Shear Strength	<input type="checkbox"/> Heat Resistance
<input type="checkbox"/> Hardness	<input checked="" type="checkbox"/> Good Machinability
<input type="checkbox"/> Impact Fatigue	<input checked="" type="checkbox"/> Thermosetting
<input checked="" type="checkbox"/> Impact Strength	<input type="checkbox"/> Vibration Absorption
<input checked="" type="checkbox"/> Moisture Resistance	<input checked="" type="checkbox"/> Good Dimensional Stability
<input checked="" type="checkbox"/> Chemical Resistance	<input type="checkbox"/> Low Thermal Conductivity
<input checked="" type="checkbox"/> Light Weight	<input type="checkbox"/> Wear Resistance
<input type="checkbox"/> Dielectric Strength	
<input type="checkbox"/> Low Dissipation Factor	

✓ Doesn't fog film

Technical drawing of a film spool with dimensions: 11/64, 1/16, 1/32, 3/2, 21/32, 7/64, 1/32, 7/32, 100, 20, 30, 18, 20, 11/16-16 TPI, #10-24 NC-2.

16 MM. FILM SPOOL OF SYNTHANE

LAMINATED PLASTIC RESISTS PHOTOGRAPHIC

CHEMICALS, HOLDS SHAPE, DOESN'T FOG FILM.

The film spool we're talking about is one used in the processing of movie film. The material for this spool has to be light in weight, strong and easily machined. Since it is always in contact with film and photo solutions, it must also be chemically-resistant and—most important—not fog the film by chemical contamination.

This isn't an easy assignment for any material, but *Synthane* fills the bill.

Whenever you want parts requiring many properties, consider how *Synthane's* combined benefits may help you improve your product.

Synthane produces finished parts from many different grades of *Synthane* laminated sheets, rods, tubes and molded-laminated and molded-macerated parts. Service and quality characterize *Synthane* fabrication.

We can handle the whole job for you from your print to the finished part—eliminating your tooling-up, reject and machining problems—and producing parts of excellent quality at a saving of your time and money.

For more information about *Synthane* grades, properties and fabrication facilities, send in the coupon.

SYNTHANE CORPORATION, 13 River Road, Oaks, Pa.

Please rush me more information about *Synthane* laminated plastics.

Name _____

Title _____

Company _____

Address _____

City _____ Zone _____ State _____

SYNTHANE
 LAMINATED **S** PLASTICS

SYNTHANE CORPORATION • OAKS, PENNSYLVANIA

More and better jobs for more people

GENERAL MOTORS President Harlow H. Curtice speaking:

"Just as an example of how job opportunities in General Motors have grown, here is what has happened since 1940.

"In 1940, we had 233 thousand employes on our payrolls in the United States and Canada. In 1955, our employment totals 520 thousand—an increase of 287 thousand good jobs in only 15 years."

It stands to reason that a climate where job opportunities expand with such rapidity must be especially fruitful of career opportunities for young men holding engineering degrees.

For, in the final analysis, the very life's blood of our organization is the never-ending production of "more and better things for more people"—and that, very definitely, requires the engineering mind at its best.

In point of fact, although engineering

graduates comprise a mere two per cent of total GM employment, they will eventually fill about forty per cent of executive posts if the established pattern continues.

Why not, then, look into the possibility of enjoying a rewarding career as a GM engineer? You'll be interested in a big new 136-page handbook entitled, "Job Opportunities in General Motors." Your college library or placement office should have it.

GM Positions Now Available In These Fields:

MECHANICAL ENGINEERING
ELECTRICAL ENGINEERING
CHEMICAL ENGINEERING
METALLURGICAL ENGINEERING
INDUSTRIAL ENGINEERING

GENERAL MOTORS CORPORATION

Personnel Staff, Detroit 2, Michigan

THE CORNELL ENGINEER

The New Electron-Synchrotron

by ARTHUR H. VAUGHAN, EP '57

In the news recently has been the announcement by Prof. Robert R. Wilson, director of the Newman Laboratory of Nuclear Studies, of the successful first test of Cornell's newly completed electron-synchrotron (coverphoto). This machine incorporates a new and highly important development in its mechanism for maintaining electrons in a circular orbit during acceleration. In addition, the electron-synchrotron, after nearly two years of construction, happens to be the most powerful of its kind (it is an *electron* accelerator) in existence at present. At full power, the machine can eject a beam of electrons having energies up to about one and one half billion electron volts.*

Difficulties experienced by the now-antique "cyclotron", due to relativistic effects on the masses of the electrons at velocities close to the velocity of light, require the use of synchrotron-type, rather than cyclotron-type, accelerators, when high energies are demanded and light-weight particles, such as electrons, are to be used as "projectiles". The cyclotron depends upon the accelerated particles keeping constant mass in order to stay "in step" with the accelerator oscillator. The synchrotron does not have this defect.

Strong-Focusing Technique

Recent experience with the Brookhaven Cosmotron, supplemented by development concepts of scientists at Cornell and elsewhere, has made it practicable to construct accelerators having far greater capacities at costs much less than heretofore. The new development, being pioneered by Cornell, is to be known as "strong focusing", and makes possible great reduction, in magnet sizes from those in conventional accelerators. The development of machines of this kind represents a tremendously important boost to nuclear studies.

The Cosmotron experience revealed that a beam of charged particles passing through a magnetic field of special shape can be made to hold to a very tight course, i.e., to a circular orbit of small diameter.

This is done by alternately focusing and de-focusing the beam of particles. The strong-focusing apparatus consists of a series of lenses, analogous to optical lenses, referred to as "alternating gradient" lenses, to stabilize the electrons in their orbit. The energy for the machine is developed by an RF oscillator, working at 80 megacycles. The requirement of a smaller orbit enables the physicists to produce more energy with a smaller machine. The new device at Cornell is 26 feet in diameter. Its main magnet, weighing 20 tons, is much lighter than the magnets of conventional machines of comparable power.

Because strong-focusing apparatus can be used to accelerate protons as well as electrons (in a proton-synchrotron), it is believed that the principle will enable us to construct accelerators capable of reaching energies on the order of 25 billion e-v.

The Cornell electron-synchrotron, now operating at half power, will be pushed up to full power in stages. Full scale operation is expected some time this summer.

Electrons are injected into the Cornell machine's "doughnut" by a van der Graaff electrostatic generator, at 30 pulses per second and about two million e-v. The electrons are then caused to circle the synchrotron, by means of electromagnetic fields, for a total time of about .012 seconds. During this time they circle their orbit close to 120,000 times, and travel a distance of about 2000 miles.

After acceleration, the electrons possess velocities of about 98 percent the speed of light. Their masses are about 2000 times as great as those of electrons at rest. Their energies are about one billion e-v. After this stage, further increases in energy serve essentially only to increase the masses, rather than the velocities, of the electrons.

Finances

The actual cost of this machine is meaningless, since it contains many parts from Cornell's older, 300 MEV (million e-v), accelerator, now dismantled. To build

the usual synchrotron would cost 400 to 500 thousand dollars, which is approximately the total investment represented by both the old and the new Cornell accelerators. Construction of the electron-synchrotron has been the program of a joint agreement of the University, the Atomic Energy Commission, and the Office of Naval Research.

Experimental Program

Facilities of the electron-synchrotron will be available to graduate students at the University, and will aid considerably in speeding up the program of experimental work undertaken by students working on advanced degrees in physics. There is ample space for the preparation of experiments near the machine while other experiments are in progress. The glass "beam tube" may be "tapped" for electrons at any of several locations on the machine's circumference.

Cornell physicists are at liberty to use the machine for any experiments they wish to perform, and are in charge of its operation. No secret or classified work will be done, either on the synchrotron or on the Ithaca campus of the University. The synchrotron will be used to a large extent for investigations into the nature of elementary particles, especially the so-called mesons and associated nuclear forces, and negative electrons, as well as certain other transitory particles. It is possible to cause the synchrotron beam to strike a metallic target to produce high-energy x-rays or gamma rays, also to be used for study. Copies of reports on research involving the electron-synchrotron will be sent to the Office of Naval Research as they go to scientific journals, as a part of the sponsorship agreement. Many of the experiments to be performed are repetitions, or extensions on a higher energy level, of experiments previously performed on the old synchrotron, and discoveries of new phenomena are to be anticipated.

*The "electron-volt", abbr. "e-v", is a unit of energy. One billion e-v 1.18×10^{-10} foot pounds, or 4.45×10^{-14} watt-hours.

CORNELL SOCIETY OF ENGINEERS

107 EAST 48TH STREET

1954-55

NEW YORK 17, N. Y.

WALTER M. BACON, E.E. '30, *President* 510 East 84th St., New York 28, N. Y.
WILLIAM M. LEONARD, M.E. '24 *Executive Vice-President*
4 Irving Place, New York 3, N. Y.
WALTER L. HARDY, Ch.E. '38 *Secretary-Treasurer*
431 East 20th St., New York 10, N. Y.
RICHARD W. EUSTIS, Ch.E. '43 *Recording-Secretary*
2 Russell Road, Fanwood, N. J.

Delaware Valley Branch

LEWIS R. GATY, E.E. '23, *Vice-Pres.* 100 Chestnut St., Phila. 25, Pa.

New England Branch

J. RUSSELL CLARKE, JR., M.E. '25, *Vice-Pres.* Westford Rd., Concord, Mass.

New Jersey Branch

JOHN WEIKART, Ch.E. '42, *Vice-Pres.* 714 Woodland Ave., Westfield, N. J.

Chicago Branch

CARROLL R. HARDING, *Vice-Pres.* Merchandise Mart Plaza, Chicago 54, Ill.

Detroit Branch

I. WOOLSON, M.E. '26 P.O. Box 1628, Detroit 31, Mich.

St. Louis Branch

ARTHUR J. LEUSSLER, M.E. '23, *Vice-Pres.* 30 Rio Vista Dr., Clayton 5, Mo.

Honorary President: S. C. Hollister, Dean of the College of Engineering

Honorary Vice Presidents:

C. R. Burrows, Director of the School of Electrical Engineering

N. A. Christensen, Director of the School of Civil Engineering

H. J. Loberg, Director of the Sibley School of Mechanical Engineering

F. H. Rhodes, Director of the School of Chemical and Metallurgical Engineering

W. R. Sears, Director of the Graduate School of Aeronautical Engineering

L. P. Smith, Director of the Department of Engineering Physics

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates, and former students and to establish closer relationship between the college and the alumni."



Walter M. Bacon

The Cornell Society of Engineers congratulates you and wishes you the very best of luck, future prosperity, and satisfaction in your chosen profession. The past five years of study have been hard ones for you but at the same time they have been years of important accomplishment. Due to the recent tremendous increase in technological knowledge you have had to learn and become familiar with a great deal more than those who graduated before you, but your five years at Cornell have equipped you well to meet the demands that will be placed upon you. Today a very serious and dangerous shortage of trained engineering and scientific personnel in this country provides you with great opportunities. You are fortunate that your services are in such demand and that you have, with the exception of military service, almost a free choice of the type of work you will do and the location where you will do it. This same shortage which gives you these advantages, however, imposes on you at the same time a tougher job to do in that the future prosperity and security of this nation depends on your doing more than might be considered your fair share of work.

Those of you who are fortunate enough to be able to continue your studies at the graduate level are preparing yourselves to fill very important jobs of a more specialized nature in the next few years. The shortage of specialists is equally severe and the demands for them in both the industrial and the teaching fields is just as great.

The Society hopes that after graduation you will have a continuing interest in your University and its problems and that you will take an active part as a loyal and interested Alumnus in supporting, encouraging, and guiding the work that it does now and will do in the future. We also hope you will take advantage of this Society's interest in you and use it as a means of keeping in contact with your fellow Cornell engineers and the progress of the Engineering College. We hope you will try and interest properly qualified young men to study engineering at Cornell so that we may continue to maintain a strong body of Alumni of whom we all may be proud. We of the Society know we can be of value to you and will be able to help you with your future problems and we will welcome you as new members.

W. M. BACON

ALUMNI ENGINEERS

Leon Buehler, Jr., M.E. '21, Chief Refrigeration Engineer, Creamery Package Manufacturing Company, Chicago, Ill., was installed as President of the American Society of Refrigerating Engineers at the Society's 50th Annual Meeting held at the Hotel Benjamin Franklin, Philadelphia, Pa.

Mr. Buehler is the holder of about 25 patents on refrigeration equipment and processes. He is currently Chairman of the ASRE Membership Relations Committee, and formerly has been Chairman of Chicago Section and of the Program, Standards, General Technical, and Membership Committees. He has been a speaker at many of the Society's national and Section meetings and has contributed numerous technical articles to various magazines. Life membership in the Society was granted him this year.

Carlyle M. Ashley, M.E. '24, Chief Development Engineer, Carrier Corporation, Syracuse, N. Y., was installed as First Vice President of the ASRE.

Mr. Ashley joined the Carrier Corporation in 1924. Now Chairman of the Technical Coordinating Committee, he had some years' experience as Chairman of the Research Committee which is responsible for granting ASRE funds for research projects in refrigeration and air conditioning to educational institutions.

Mr. Ashley was Treasurer in 1953 and has also served as Chairman of the Finance Committee and of the Program Committee. A member since 1937, he was elected a Director at Large in 1948.

Joseph R. Chamberlain, M.E. '28, Chief Engineer, Industrial Products, York Corporation, York, Pa., was installed as Director of the American Society of Refrigerating Engineers.

Mr. Chamberlain has been associated with the York Corporation since he worked as a student engineer in 1928. In the past he has served as Chairman and Vice Chairman of the Standards Com-

mittee and has been active in the writing of standards. Mr. Chamberlain is chairman of the American Standards Association's B9 interpretations subcommittee. Co-authorship of a 1941 national meeting paper is also to his credit, and he has written numerous other articles and papers.



J. R. Chamberlain

The appointment of **Theodore C. Ohart B.S. in M.E., '29**, as Manager — Marketing of General Electric Company's Silicone Products Department was announced recently.

Joining General Electric in 1929, Mr. Ohart completed the Company's Advanced Engineering Course. During its three-year curriculum, he executed assignments in engineering and manufacturing at Schenectady, N. Y.

Following assignments in the Schenectady Works laboratory, Mr. Ohart did application engineering work in the Lamp Division at Nela Park, Cleveland, O. He went on active duty with the U. S. Army in 1940, and was discharged in 1945 with the rank of major in the Ordnance Department.

After service, he returned to the G-E Lamp Division as its Buffalo

district engineer. His post as Division retail sales manager preceded his present appointment.

William Leigh Cook, West Moreland Depot, N. H., M.E. '00, died December 15, 1954. He retired in 1936 after more than thirty-five years with New York Telephone Co. and later with New Jersey Bell Telephone Co. He was a member of Sigma Chi.

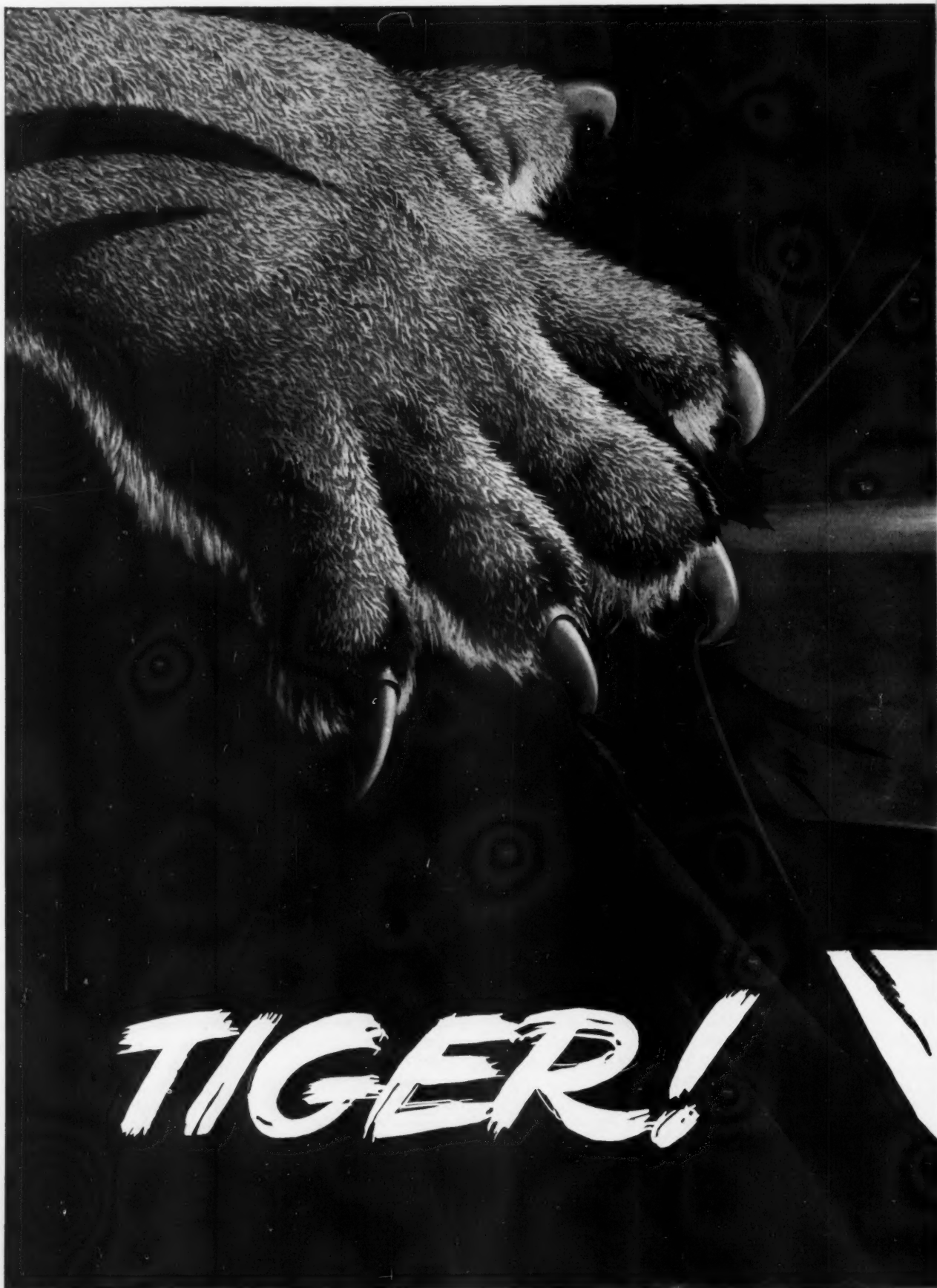
Clarence James Pope, 399 Tremont Place, Orange, N. J., M.E. '04, died January 13, 1955. Retired as senior engineer of the New Jersey Public Utilities Commission, he was active on the secondary school committee of the Alumni Association and in the Cornell Club of Essex County. He received the Carnegie Medal for heroism in the Chi Psi fraternity house fire of 1906 in which seven students perished.

Isador Fried, C.E. '10, 65 Glenview Avenue, Toronto, Canada, died July 22, 1954. A contractor for the last thirty-four years, he had constructed many buildings in Canada, including federal buildings, post offices, and the largest synagogue in Canada. In 1950, he attended the Forty-year Reunion. He left a bequest of \$500 to the University.

Kerr Atkinson, M.E. '12, a consulting engineer who lives at 85 Ledgeways, Wellesley Hills, Mass., has been awarded a certificate of merit for his entry in a contest sponsored by The American Society of Mechanical Engineers to find a symbol for its seventy-fifth anniversary celebration in 1955. Atkinson's design, which was judged as best from all the New England States, shows a wheel, square, well pump rig, power plant, and airplane projecting out of radiant arcs and log progress curves. It symbolizes the evolution of technical progress from primitive darkness to the light of today, achieved by the diverse activities of the mechanical engineering profession.

George W. Tall, M.E. '13, 330 Bickley Road, Glenside, Pa., was

(Continued on page 34)





GRUMMAN, 25 years old this year, needs young engineers to work on the Navy's new supersonic Tiger. To learn about all the advantages offered by Grumman and by Long Island as a place to live and play, send for your copy of the new 26-page booklet: Engineering For Production.



ENGINEERING DEPARTMENT, Grumman Aircraft Engineering Corporation
Bethpage, Long Island, New York

Name

University

Grad. Year ..

Street

City

State

GRUMMAN AIRCRAFT ENGINEERING CORPORATION

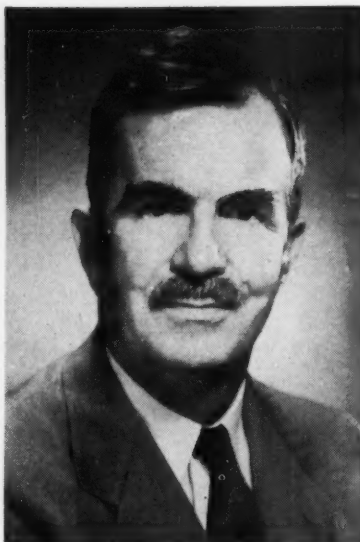
Designers and builders also of transonic Cougar jet fighters, S2F sub-killers, Albatross amphibians, metal boats, and Aerobilt Truck bodies.

Alumni Engineers

(Continued from page 31)

elected a director of the National Association of Manufacturers at its annual meeting in New York. He represented Scientific Apparatus Makers Association and the Manufacturing Trade Group of the National Industrial Council.

After Tall graduated from Cornell he was with United Gas Improvement Co. in Philadelphia until 1915, when he went with Leeds & Northrup Co., Philadelphia, whom he has been with ever since. In 1944, he became vice-president in charge of sales, and in 1953 was also elected secretary. He is a director of the Scientific Apparatus Makers Association and a member of the executive committee of its Recorder-Controller Section. He is also a member of Industrial Heating Equipment Association, Instrument Society of America, American Society of Metals, Franklin Institute,



C. M. Ashley

and the Rotary Club of Philadelphia.

Harold G. Meissner, ME '17 is in the engineering department of Combustion Engineering, Inc., New

York City. He lives at 61 Dell Avenue, Mt. Vernon.

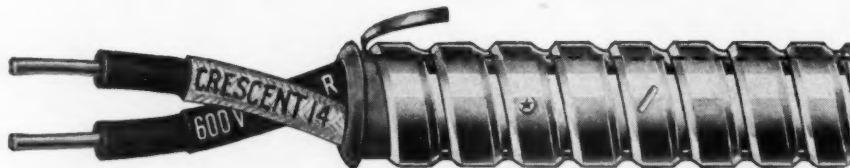
Captain Robert E. Bassler, CE '17, CEC, USN (Ret.), is public relations officer for University of Tampa. He retired in 1953 after thirty-six years with the Navy.

J. Paul Blundon, CE '17, has recently been placed on the retired list of the U.S. Naval Reserve with the rank of Rear Admiral. During World War II he served in the Civil Engineers Corps of the U.S. Navy.

Colonel Philip R. Garges, CE '26, USA (Ret.), is staff engineer for The Citadel, Charleston, S.C. military college. Colonel Garges retired from active duty with the Army Corps of Engineers last year after thirty years of service.

Sanford W. Seidler, EE '46, and Mrs. Seidler (Jean Gordon '49) are living at 134 Haven Avenue, New York 32. Seidler is a senior engineer with W. L. Maxson Corp. of New York.

CRESCENT ABC ARMORED CABLE



Prefabricated Break Lines

The Cut Mark (at 1 1/2" intervals) shows the location of a prefabricated breaking line inside the armor. Only a few strokes of a file or saw guided by the Cut Mark are required to cut through one outer ridge, and a bend by hand severs the armor. This results in a clean separation with no sharp edge—a safer, easier and faster job. The prefabricated breaking lines are so designed that there is *no reduction* in tensile strength, bending quality, crushing resistance and electrical conductivity of armor.

Bond Strip Under Armor

Permanently low armor resistance is provided in sizes No. 14 and 12 AWG by use of a flattened, bonding wire which is in contact with the under side of each convolution.

CRESCENT INSULATED WIRE & CABLE CO.
TRENTON, N. J.

Cliff Litherland asks:

Would I have
varied assignments
at Du Pont—or
would I specialize
technically?



ARTHUR I. MENDOLIA was graduated from Case Institute in June 1941 and started work with the Du Pont Company that same month. In addition to handling challenging assignments at work, he also enjoys some interesting hobbies. Although he makes no claims personally, he's classed as a minor authority on golf and hi-fi music. Mr. Mendolia is Assistant Director of Research for Du Pont's *Electrochemicals Dept.*

WANT TO KNOW MORE about working with Du Pont? Send for a free copy of "*Chemical Engineers at Du Pont*," a booklet that tells you about pioneering work being done in chemical engineering—in research, process development, production and sales. Write to E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Building, Wilmington, Delaware.



BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

WATCH "CAVALCADE OF AMERICA" ON TELEVISION



CLIFFORD LITHERLAND received a B.A. degree from Rice Institute last year, and is now working for a B.S. in Chemical Engineering. He is Business Manager of "*The Rice Engineer*," and Vice-President of the fifth-year class at Rice. By asking questions of prospective employers, Cliff is trying to get information that will help him make the best use of his training in the years ahead.

Arthur Mendolia answers:

Well, Cliff, I'd say the answer to that question depends largely on your own preferences. In a company the size of Du Pont there are opportunities for growth along either line.

In my own case, I've followed the route of diversification—and I think you'll find that's the general procedure when a fellow is interested in administrative work.

For example, after graduation I started work in the research lab at Du Pont's Niagara Falls plant. That was followed by two years of process improvement work, and a stretch as assistant supervisor over one of the plant areas. Next, I spent a few years in liaison on the design and construction of our first full-scale plant for making nylon intermediates from furfural. Then, I had assignments on "plant start up," and production supervision before I was given my present post. I was made Assistant Director of Research for Du Pont's *Electrochemicals Department* last August.

You see, variety of assignments means contact with new men and with constantly changing problems. That keeps interest alive. It leads to growth, too, because it provides a broad base of experience for future responsibilities.

On the other hand, some fellows prefer to become specialists in a particular field—and Du Pont has many opportunities for that type of professional growth, too. In our research, development and design groups we have experts on distillation, mass transfer, thermodynamics—and most anything else you'd care to mention in the field of engineering. These men are respected throughout the whole company for their technical knowledge.

Whichever route you choose, Cliff—broad or specialized—you'll find that a job well done leads to satisfaction and advancement at Du Pont.



ENGINEERING WRITING

Here is an ideal way for the engineer or physicist with some aptitude for writing to enter the field of advanced electronics. In this relatively new and expanding area you can make immediate and effective use of your academic training while acquiring additional experience.

HUGHES
RESEARCH AND
DEVELOPMENT
LABORATORIES

Hughes Research and Development Laboratories are engaged in a continuing program for design and manufacture of integrated radar and fire control systems in military all-weather interceptor aircraft. Engineers who produce the maintenance and operational handbooks for this equipment work directly with engineers and scientists engaged in development of radar fire control systems, electronic computers, and other advanced electronic systems and devices.

Your effort in the field of engineering writing through these publications transmits information to other engineers and technical personnel on operation, maintenance and modification of Hughes equipment in the field.

You will receive additional training in the Laboratories at full pay to become familiar with Hughes equipment. Seminars are conducted by publications specialists to orient new writers. After-hours graduate courses under Company sponsorship are available at nearby universities.

SCIENTIFIC AND
ENGINEERING STAFF

Culver City, Los Angeles County, California

Photograph above: Engineer-writer John Burnett (left) works with engineers John H. Haughwout (right) and Donald King to compile handbook information.

CORRECTIONS

Last month several printing errors were included in "Telegraph Carrier Systems", by John F. Ahearne.

The indicated expressions should read as follows:

Equation 4, page 7:

$$i_b = K(E_b + uE_c)^2 + a_1 A \sin Vt + a_1 B \sin Ct + a_2 A^2 \sin Vt + 2a_2 AB \sin Vt \sin Ct + a_2 B^2 \sin^2 Ct$$

Equation 7, page 13:

$$i_o = (a_1 e_c + a_1 \frac{e_v}{2} + a_2 e_c^2 + a_2 e_c e_v + a_2 \frac{e_v^2}{4}) - (a_1 e_c - a_1 \frac{e_v}{2} + a_2 e_c^2 - a_2 e_c e_v + a_2 \frac{e_v^2}{4})$$

Equation 10, page 14:

$$I = \frac{A \sin Vt}{2(R_1 + R_2)} + \frac{2A}{\pi(R_1 + R_2)} [\sin Vt \sin Ct + \frac{1}{3} \sin Vt \sin 3Ct + \frac{1}{5} \sin Vt \sin 5Ct + \dots]$$

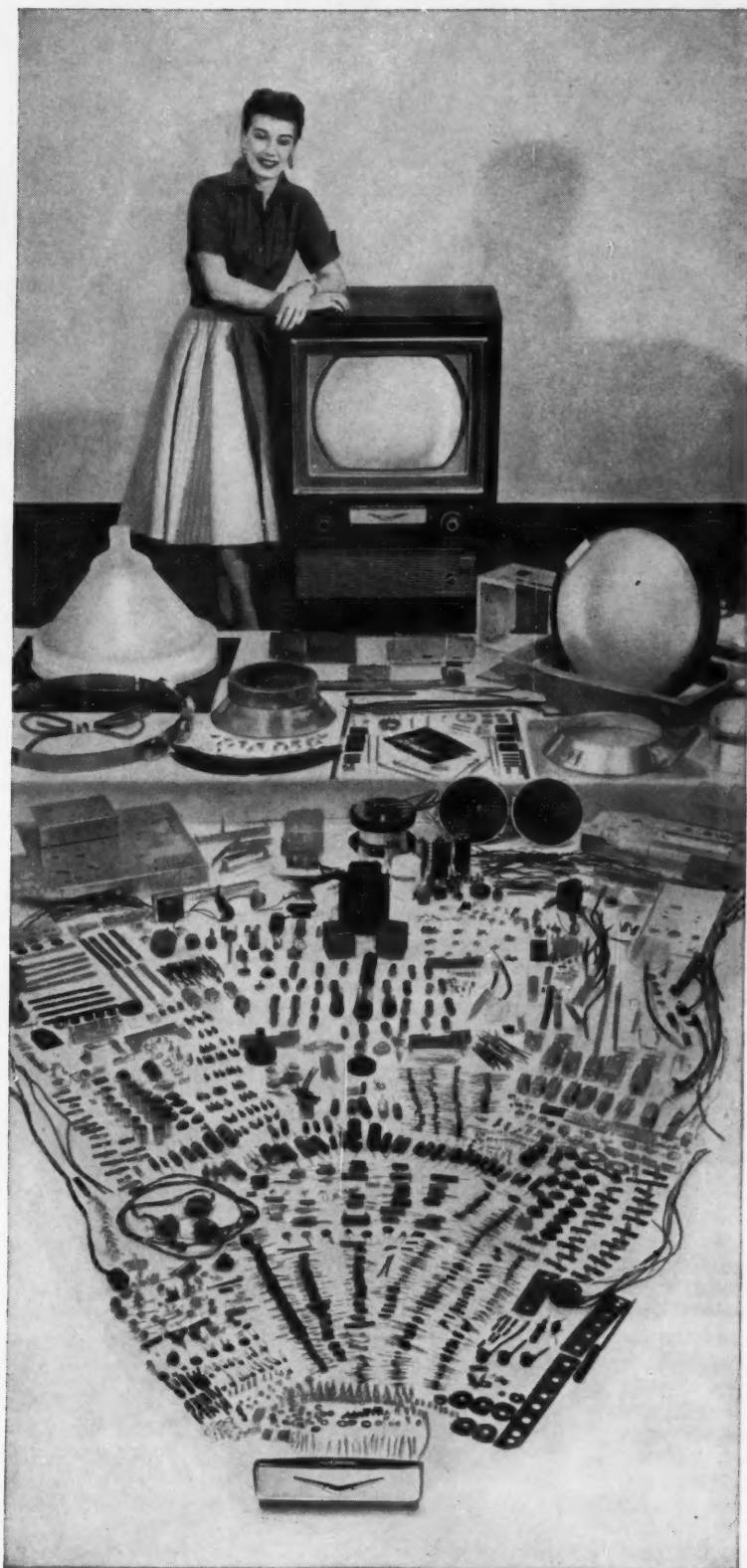
Equation 11, page 14:

$$I = \frac{A \sin Vt}{2(R_1 + R_2)} + \frac{A}{\pi(R_1 + R_2)} [\cos(C-V)t - \cos(C+V)t + \frac{1}{3} \cos(3C-V)t - \frac{1}{3} \cos(3C+V)t + \frac{1}{5} \cos(5C-V)t - \frac{1}{5} \cos(5C+V)t + \dots]$$

Equation 12, page 54:

$$I = \frac{2A}{\pi(R_1 + R_2)} [\cos(C-V)t - \cos(C+V)t + \frac{1}{3} \cos(3C-V)t - \frac{1}{3} \cos(3C+V)t + \frac{1}{5} \cos(5C-V)t - \frac{1}{5} \cos(5C+V)t + \dots]$$

Credit for all pictures: *The American Telephone and Telegraph Company*, through the courtesy of *Southern New England Telephone Company*.



**This picture
shows how RCA
helps small
manufacturers
grow**

Today the inter-dependence between manufacturer and supplier is stronger than ever in the history of American business. For in the challenging new age of electronics, hundreds upon hundreds of component parts are needed in the manufacture of new products.

For example, the superb new RCA Victor 21-inch color TV set shown here contains 2,070 parts. These are made by 600 different suppliers, most of whom are small businesses.

Indeed, more than three-quarters of all RCA suppliers are small business firms that receive nearly one-half of RCA's purchasing dollars. They, in turn, have their suppliers of raw materials. Thus through a long line of co-operative effort, employment is provided for countless people in many fields—and an entire economy benefits.

RCA salutes its full roster of 7,500 suppliers, located in 43 states, for their inventiveness and resourcefulness that contribute so much to the quality and performance of its products. With these firms at our side, RCA continues to march forward, creating new and better "Electronics for Living"—electronics that make life easier, safer, happier.

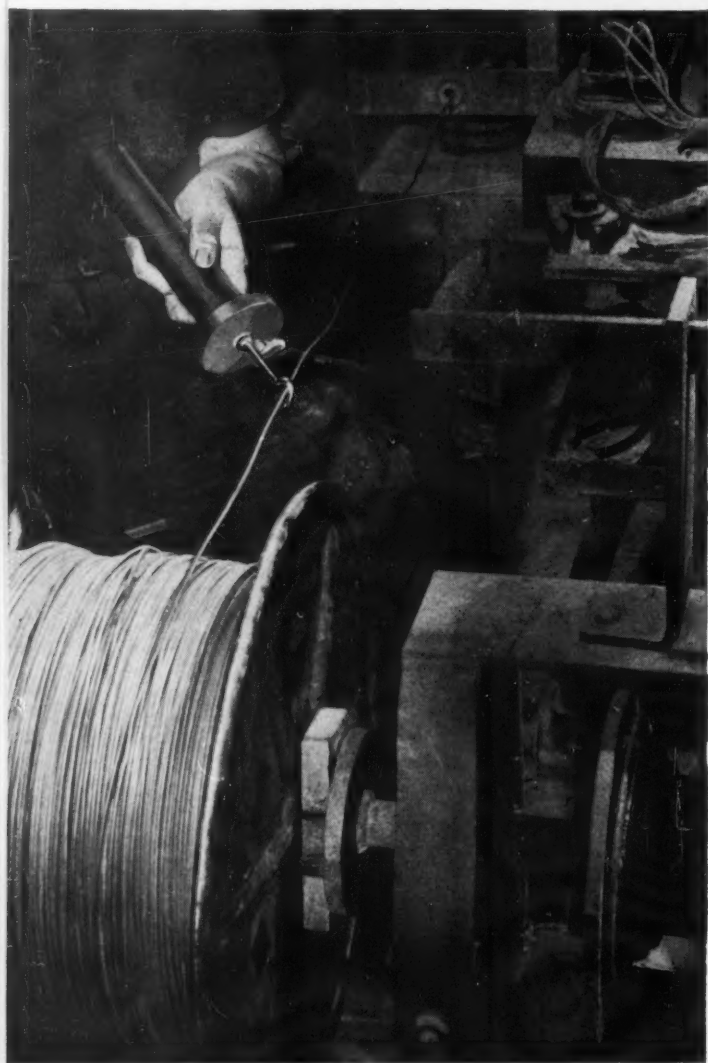
WHERE TO, MR. ENGINEER?

RCA offers careers in research, development, design, and manufacturing for engineers with Bachelor or advanced degrees in E.E., M.E. or Physics. For full information, write to: Mr. Robert Haklisch, Manager, College Relations, Radio Corporation of America, Camden 2, N. J.



RADIO CORPORATION OF AMERICA
ELECTRONICS FOR LIVING

Factory testing of "U.S." electrical wires and cables



CABLE TESTING (Part I)

It has been indicated in a previous section of this series entitled "Cable Specifications" that practically every element of insulated electrical wires and cables may be covered by some specification requirements. Numerous tests are, therefore, necessary to determine the suitability of such cables for the application for which they are designed. These tests may be conducted on (a) the cable elements during manufacture, known as preliminary tests, (b) the completed cables at the factory, final tests, and (c) after installation. Some of the preliminary and final tests at the cable factory such as conductor resistance, high voltage, insulation resistance and corona level are, generally, non-destructive tests and may be conducted on each entire length of cable manufactured. Other tests, such as insulation and sheath thickness, physical, aging, moisture, resistance, ozone resistance, capacity and power factor, short-time dielectric strength and cold bending and long-time dielectric strength tests are made on short samples selected from a lot of cable.

No. 9 in a series



UNITED STATES
ELECTRICAL WIRE & CABLE DEPARTMENT

The following is a general description of these tests and their significance as applied to insulated electrical wires and cables. Details of the test equipment required and the specification requirements are not discussed since they are covered by industry publications such as those of the American Society for Testing Materials and the Insulated Power Cable Engineers Association.

FACTORY TESTS

Factory tests are performed for the following purposes: (1) to determine whether the materials of which the cable is made have the required quality; (2) to determine whether the manufacturing processes such as wire drawing, annealing, compound mixing, insulation extrusion and vulcanization have been performed properly; (3) to detect partial or incipient faults that may have accidentally failed to be detected in the tests indicated in (2); and (4) to determine whether the cable meets the customer's specifications.

Tests on Entire Lengths

CONDUCTOR RESISTANCE. Test is made to insure that the conductor has the required average cross-sectional area and, hence, that its resistance does not exceed the allowed maximum.

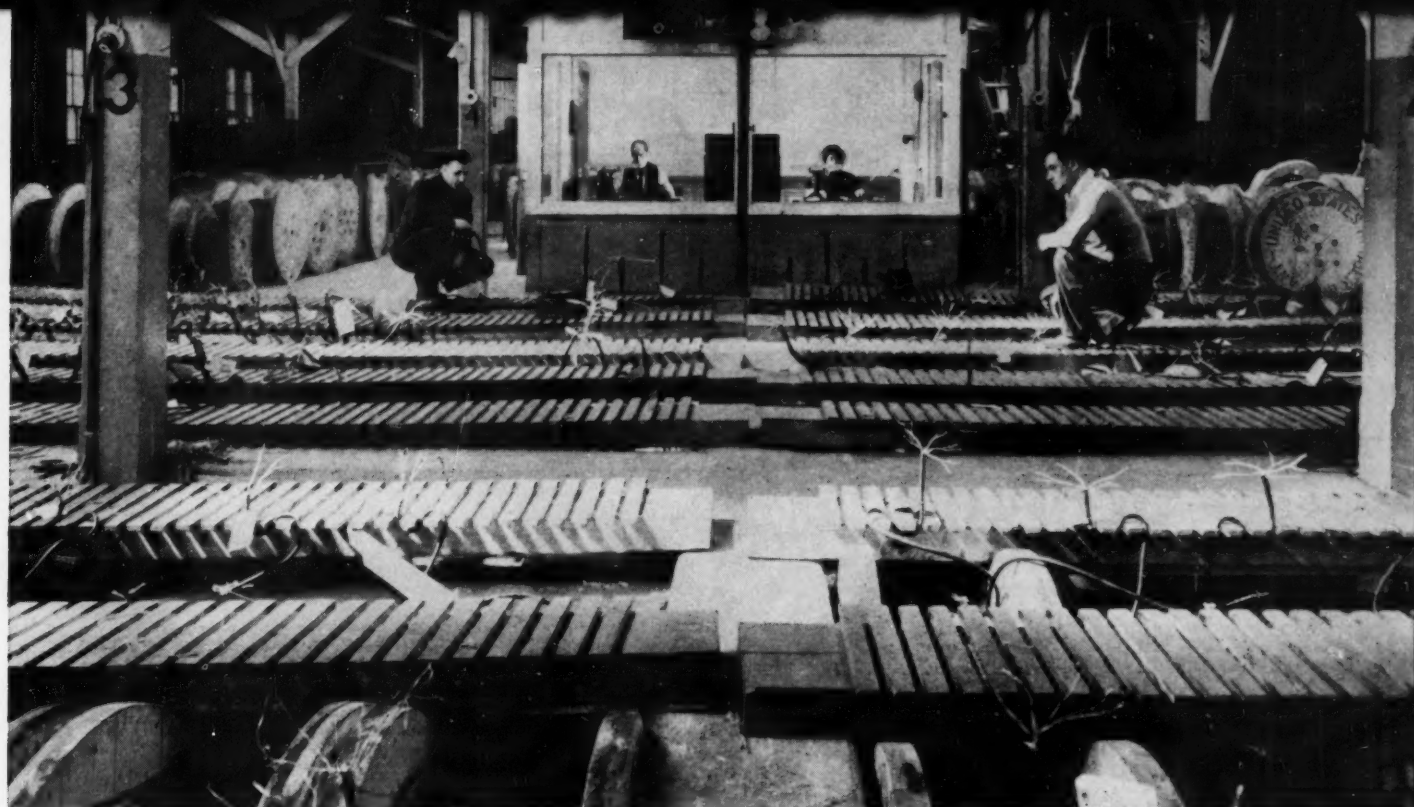
SPARK TESTING. The entire length of insulated conductor is subjected momentarily to a high potential to detect and permit the repair of imperfections in the insulation that might cause failure on subsequent voltage and insulation resistance tests.

HIGH VOLTAGE TEST. This test is conducted on each entire length of insulated cable to detect potential faults or weak spots in the insulation and to insure that the insulation will withstand the minimum voltage required by the specification for its rated voltage. The magnitude of the test voltage is determined by the type and thickness of the insulation as shown in the following table for 600 volt cables. The time of application is one minute for code grade insulation, and five minutes for the higher grades.

Insulation Thickness and Test Voltage for Rubber Insulations for 600 Volt Service				
Conductor Size, Awg or MCM	Insulation Thickness, 64ths Inch	Code Grade	AC Test Voltages Performance and Heat-Resistant	(KV) Ozone-Resistant
14 to 9	3	1.5	3.0	4.5
8	4	1.5	3.5	6.0
7 to 2	4	2.0	3.5	6.0
1 to 4/0	5	2.5	4.0	7.5
225 to 500	6	3.0	5.0	8.5
525 to 1000	7	3.5	6.0	10.0
Over 1000	8	3.5	7.0	11.5

Cables designed for operation at voltages above 5001 are required to withstand a d-c test voltage in addition to the a-c voltage. This d-c voltage is three times the a-c voltage for ozone-resistant insulations and it is usually applied for 15 minutes.

The high voltage test is made by applying the required voltage between the conductor and water in which the cable has been immersed for at least six hours. When metallic coverings are present, the voltage is applied between the conductor and such coverings. Any failures are repaired and the cable again subjected to the voltage.



INSULATION RESISTANCE. The insulation resistance test consists of applying a direct voltage of from 125 to 500 volts, usually from a battery, between the conductor and water in which the cable is immersed, or other ground, and measuring the current that flows through the insulation after an electrification of one minute. A suitable galvanometer is generally used for this measurement. From this current and the applied voltage, the resistance of the insulation is calculated and expressed, usually, as megohms (1 million ohms). This test is conducted after the voltage tests and, hence, serves to indicate whether the insulation failed on that test. Insulation resistance also serves to indicate uniformity in processing, particularly

insulation compounding, since a well-processed compound should give reasonably uniform insulation resistance. Most wire and cable specifications contain minimum requirements for insulation resistance so that this test determines whether or not the specification is complied with.

The resistance of insulations is inversely proportional to the temperature, that is, it is lower at high temperatures. It is, therefore, necessary to note the temperature at which the insulation resistance is measured and to apply a correction factor to reduce the resistance to a standard temperature. The insulation resistance varies with the type of insulation, its thickness and the size and length of the conductor. The following formula gives the relation between these factors.

$$\text{Insulation Resistance, Megohms} - 1000 \text{ feet} = K \log_{10} \frac{D}{d}$$

Where, D = Diameter over the insulation, inches

d = Diameter over the conductor, inches

K = A Constant for the insulation used

CORONA OR IONIZATION LEVEL. This test determines the voltage at which ionization or corona develops in a length of cable and is usually made only on cable for operation above 4000 volts. It is made by applying a gradually increasing a-c voltage between the insulated conductor and water or other ground with an oscilloscope in the circuit. Any air entrapped at the surfaces of the insulation or within the insulation will ionize when a sufficiently high voltage is applied resulting in the formation of more active oxygen or ozone. These materials are detrimental to most organic insulations particularly when such insulations are under physical tension, and thus may cause premature failure of the insulation. This ionization is indicated by the appearance of high-frequency oscillations on the charging current trace of the oscilloscope. In actual practice, the voltage at which ionization is extinguished rather than initiated is determined. For long cable life, this extinction voltage should be at least 110 per cent of the rated voltage to ground.

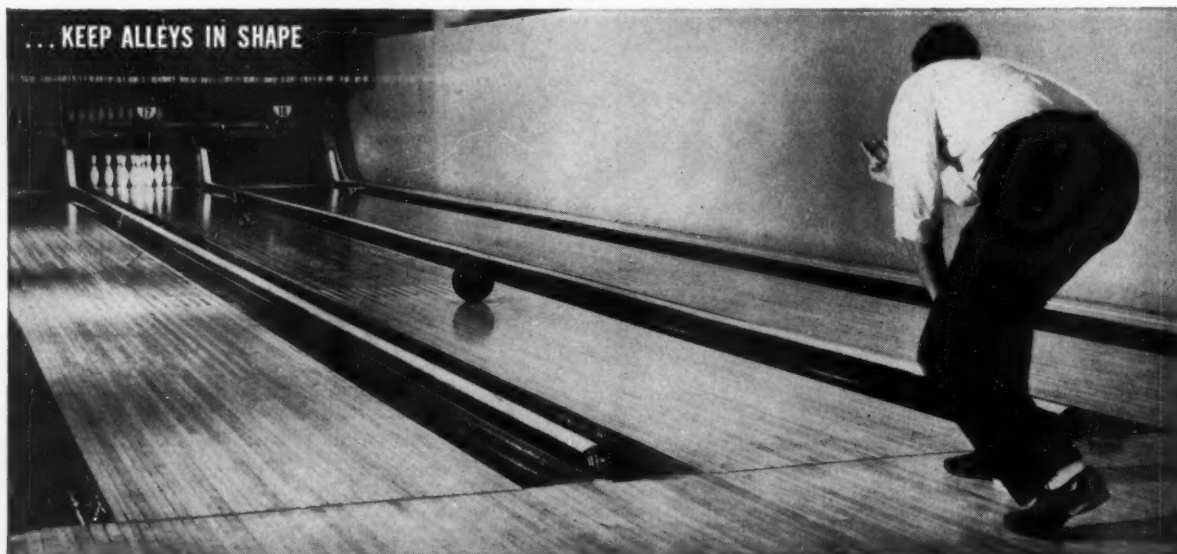
Wire and cable specifications generally require that these tests be made on the completed product. High voltage and insulation resistance tests are usually also made immediately after the insulation has been applied and vulcanized. This is general insurance that cables passing the test will meet the requirements when completed.



RUBBER COMPANY
ROCKEFELLER CENTER, NEW YORK 20, N.Y.

HOW HERCULES HELPS...

▼ **AIMING FOR THE "POCKET"**, this bowler wants the alley he uses highly polished and free of "ruts". That's why bowling alley surfaces are protected with nitrocellulose lacquer to keep them in top condition. The fastest drying protective coating known, lacquer makes it possible to put an alley back in play within hours after it has been refinished. This same tough finish protects bowling pins and other sports equipment.



HERCULES
CHEMICAL MATERIALS FOR INDUSTRY



◆ **THE BACK COUNTS, TOO**, in the manufacture of carpets. Hercules Dresinol® solvent-free resin dispersions used in conjunction with latex, starch and pigments, provide durable backings for popular-priced carpets. Dresinol furnishes either flexibility or stiffness; adds body to the carpet and improves adhesion of the backing for all types of cotton, wool and mixed fiber carpets.



◆ **NEW ANTHRACITE-BURNING BOILERS**, clean and compact, make playrooms of basements the year round; even remove ashes automatically. Mining the millions of tons of anthracite used annually for residential, commercial and industrial uses would be impossible without explosives. For more than forty years, Hercules has pioneered in blasting techniques and equipment to increase the efficient and safe use of explosives in mining, quarrying, construction, and farming.

HERCULES POWDER COMPANY

INCORPORATED

986 Market St., Wilmington 99, Del. Sales Offices in Principal Cities

SYNTHETIC RESINS, CELLULOSE PRODUCTS, CHEMICAL COTTON, TERPENE CHEMICALS,
ROSIN AND ROSIN DERIVATIVES, CHLORINATED PRODUCTS, EXPLOSIVES, AND
OTHER CHEMICAL PROCESSING MATERIALS



Cornell: Pioneer In Dynamo Development

by RICHARD BRANDENBURG EP '58

Phillips Hall, Cornell University's recently constructed electrical engineering building, marks the latest step in the progressing history in electrical engineering on the Cornell Campus. As early as 1883, when an accredited degree in electrical engineering was awarded for the first time in the world at Cornell, the University already had been the scene of many significant pioneering advances in the development of practical equipment and techniques for harnessing electric power in useful service.

In 1875 Cornell was the birthplace of the first practical dynamo for service use. Ithacans and nearby farmers were amazed as they saw two bright lights on campus shining at night over the valley. These lights were the first practical outdoor lighting system in the Western hemisphere. The dynamo story, the saga of the outdoor lighting system, and the succeeding evolution of electrical engineering study, reflect a tradition of ingenuity and practical inventive skill. As Phillips Hall this spring nears dedication, Cornellians should consider the growth of that tradition underlying the present prominent reputation of the School of Electrical Engineering.

In 1875, the basement of Cornell University's McGraw Hall became the birthplace of the first electric dynamo applicable for extended lighting service. Pioneering in the development of the machine making the Cornell campus the site of the nation's first outdoor electric lighting system were Professor William A. Anthony and George S. Moler. They based their work on the principles set forth in Europe by the Belgian electrician Z. T. Gramme, who in 1869 perfected the method of ring winding for dynamo

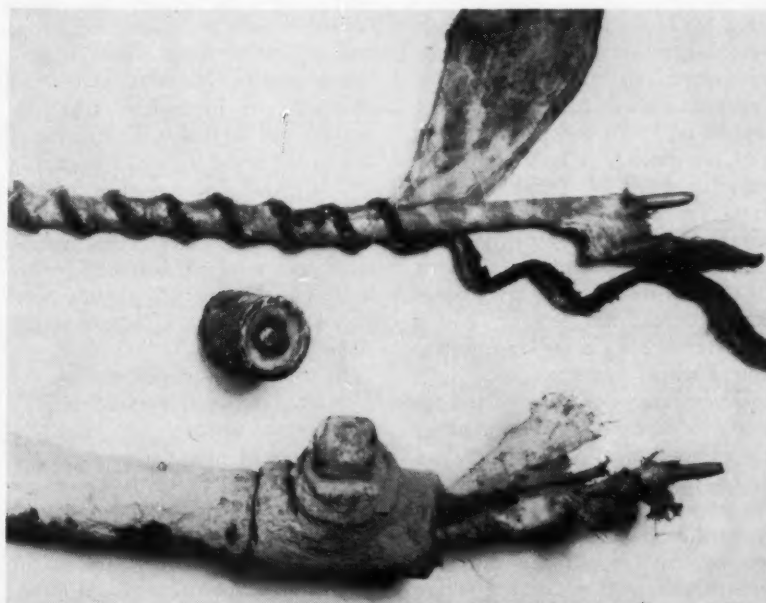
armatures. The Anthony-Moler machine was specially designed for continued laboratory operation.

Although other devices for generating electricity had been built prior to the Anthony-Moler machine, they were small experimental types. Simple arc lights had been battery powered, and European house illumination had been achieved with a "magneto machine." Although a working dynamo was constructed in America as early as 1874, the first outdoor lighting and continuous service dynamo was introduced on the Cornell campus.

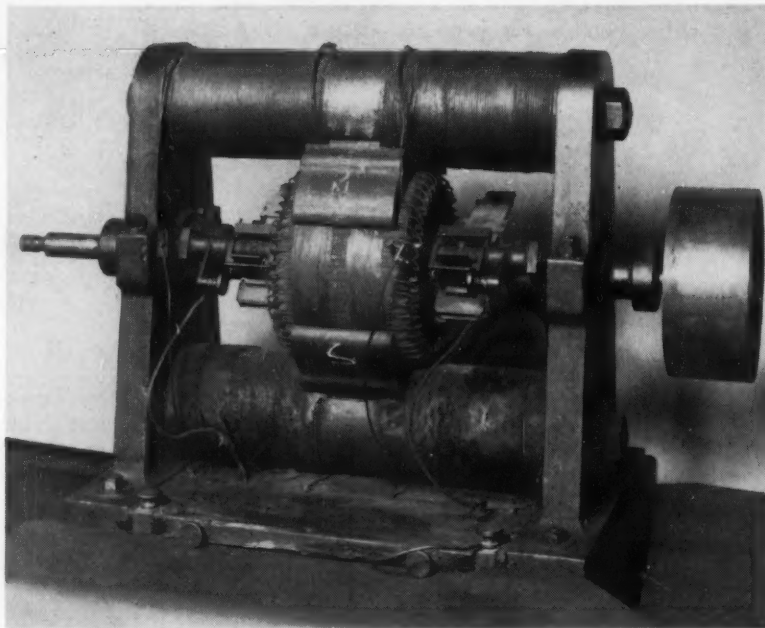
Cornell Professor E. L. Nichols, head of the physics department from 1887 to 1919, noted the revolutionary impact of the Anthony Moler design in a tribute at the time of Professor Anthony's death in 1908: "... Thus it came about

that inhabitants of remote farms among the hills of central New York saw the arc light shine out night after night long years before the introduction of this means of illumination in Paris, London, New York, Berlin, or any of the other great cities of the world."

The original installation on the campus consisted of lamps located in the tower of McGraw Hall and near Sage Chapel. The two-lamp lighting system shone down from its hill-top location to the amazement of the Ithaca townspeople. However, Ithacans had been introduced to electric lighting by the machine before it was used for outdoor illumination on Campus. After the dynamo was exhibited at the Centennial Exposition in Philadelphia in 1876, it was returned to Cornell for use in arc lighting dem-



The underground cable used in the campus lighting system consisted of gas pipes containing copper wires wrapped with muslin strips. A beef tallow packing was used, contributing to the cable's excellent durability.



The Anthony Moler dynamo, first practical dynamo for extended service operation.

onstrations in the physics laboratory. When a lighting demonstration took place late in 1878 in the Williams Brothers Machine Shop in downtown Ithaca, the *Ithaca Journal* reported that the apparatus "caused the place to be crowded with spectators each afternoon as soon as the brilliant flame had been lighted."

By 1879 the dynamo had been pressed into service as a part of the campus lighting system. The generator was run by a water wheel located in Fall Creek Gorge. The machine itself was housed in the gorge in back of Franklin Hall. Wires on poles first carried the current from the gorge to McGraw Hall. However, after objections to the "unsightly wiring" from some of the humanities faculty, Moler and Anthony developed an underground wiring system.

The underground wiring itself reflected significant engineering progress. The cables consisted of gas piping through which copper wire was passed. The wire was insulated by muslin strips and a packing of beef tallow was pumped into the pipes through taps located along their lengths. The cables were so well constructed that sections dug up by workmen in 1939 were found

to be in excellent operating condition.

Though the dynamo performed consistently, the lamps themselves were erratic. The late Charles Hull, professor of history at Cornell, recalled the "buzzing and sputtering" of a typical bulb, and observed: "If you had seen it, you never would have called it a single lightbulb. It was an open arc lamp, and its carbons were not copper-cased pencils, but flat plates, so that an arc, instead of traveling around and around to fit irregularities in the wear, jumped backwards and forwards along their edges, from one point to another of their approximate contact. Polychromatic flames resulted, startling to behold. The dynamo was already good . . . but the lamp still needed the rod of correction."

In spite of its imperfections, the pioneer system impressed nearby farmers and townspeople. That Ithacans looked optimistically to the future of outdoor lighting was reflected in the *Ithaca Journal's* "Town Talk" column early in 1879: "Three such electric lights as the one in McGraw tower would illuminate the village as brilliantly as gas does now. In order to obtain the desired results, the steeples of

the churches might be used as electric lamp posts, making them useful as well as ornamental."

The dynamo itself was a practical application of the fundamental ideas first stated by Faraday. Faraday noted that an electromotive force was produced when a metal plate was rotated near a magnet. An entry in Faraday's diary observed, "So long as the wheel moves electricity is evolved . . . It is not the mere vicinity (to magnets) but motion that evolves the electricity. Must consider this more presently. Could build a machine up this way."

Such a machine was the Anthony-Moler device, having a capacity of 20 amperes at 150 volts. The dynamo continued to operate the campus lights for about ten years until it was replaced by a new Weston dynamo. The original equipment was then used to furnish laboratory current and provide motive power for the physics department machine shop.

The dynamo was used for pur-

Former Professor George S. Moler



THE CORNELL ENGINEER



1927—Unloading cargo
from Boeing mail plane

1955—Loading Boeing C-97 Stratofreighter

There's plenty of variety in Boeing engineering careers

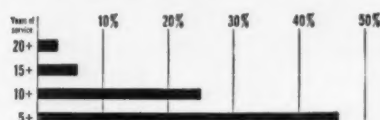
America's pioneer passenger-cargo aircraft, the 40A, was a Boeing. So is the Air Force's versatile tanker-transport, the C-97 Stratofreighter shown above.

During the company's 38-year history, Boeing engineers have blazed new trails in the design of aerial freighters and tankers, commercial airliners, flying boats, fighters, trainers and bombers. Today Boeing continues to offer engineers a wide variety of opportunities in Research, Design and Production.

Students sometimes are surprised that Boeing's engineering staff includes those with civil, electrical, mechanical, aeronautical and other engineering degrees. Yet all find application in aviation. For

example, the civil engineer may work on airframe structure or stress. Electrical engineers find challenge in the complicated electrical and electronic systems of modern jet bombers and guided missiles. Other engineers will find similar application for their talents.

The high degree of stability in careers at Boeing is reflected in this chart.



It shows that 46% of Boeing engineers have been with the company five or more

years; 25% for 10 or more years, and 6% for 15 years.

Boeing promotes from within, holds regular merit reviews to assure individual recognition. Engineers are encouraged to take graduate studies while working and are reimbursed for all tuition expense.

Current Boeing programs include: six and eight jet bombers; America's first jet transport—the 707; F-99 Bomarc pilotless interceptor (guided missile)—and advanced projects such as the application of nuclear power to aircraft.

For further Boeing career information consult your Placement Office, or write:

JOHN C. SANDERS, Staff Engineer — Personnel
Boeing Airplane Company, Seattle 14, Wash.

BOEING
SEATTLE, WASHINGTON WICHITA, KANSAS

poses other than outdoor lighting. During the late 1870's, lecture room lanterns were operated with limelight prepared chemically from oxygen and hydrogen. The lime-light method of illumination utilized a cylinder of metal stuffed with ether-soaked cloth. Gas, consisting of a mixture of oxygen and hydrogen, was drawn through the cylinder and lighted. The ignited gas was then directed upon a piece of white lime. The radiation of the lime provided light for slide lanterns. Professors Anthony and Moler devised an apparatus using the dynamo to prepare the gases electrolytically. The equipment provided gas for lantern use in various departments on campus for many years. Today the dynamo resides in Rockefeller Hall, where it is preserved for demonstration purposes. In spite of its age, the machine still is in operating condition.

Professor Anthony also laid the foundation for a growing development of Cornell physics when he combined his genius and enthusiasm with meager available demon-

stration facilities to make the subject more meaningful to Cornell students. During his career, starting at Cornell in 1872, Anthony was instrumental in a number of other important scientific advances. He supported the idea of special courses for students of electricity, resulting in 1883 in a Trustee authorization of a program leading to a degree in electrical engineering. At the time, no other school in Europe or America offered such a course.

Anthony also effected the granting of funds to develop apparatus for the absolute measurement of electricity. A wooden building, completely free from iron was built near the west end of Sibley College. The structure housed a complete set of measuring instruments including a giant tangent galvanometer with coils two feet in diameter.

George S. Moler, who received his Cornell engineering degree in 1875, was in charge of the dynamo laboratory in Franklin Hall when

the building housed the chemistry and physics departments. Moler later taught classes in the scientific applications of photography, planning the photography laboratory formerly located on the second floor of Rockefeller Hall, and designing a large part of its distinctive equipment. Moler was one of the first Americans to make x-ray pictures. He was active with Anthony in constructing the tangent galvanometer and other current measuring equipment. In addition, Moler's many inventions included an automatic switch for an early firepump system in Rockefeller Hall.

Thus the work of Cornell Professors Anthony and Moler paved the way for the tradition of electrical engineering progress most recently marked by the completion of the new electrical engineering building, Phillips Hall. The dynamo and the pioneering lighting system were significant advances in the early development of America's electric light and power industry.

"Where Printing Gets Done"

NORTON PRINTING COMPANY

317 East State Street
ITHACA
Phone 4-1271

What's Your Sport?

**GOLF
TENNIS
SOFTBALL
BASEBALL
SWIMMING
BADMINTON**

We have equipment and clothing for all Spring and Summer sports—famous brands such as Wilson, Spalding, Dunlop, Jantzen and others.

Racket stringing by a factory-trained expert—a wide variety of nylons and guts—24 hour service where possible.

Reasonable prices for fine quality at your sporting goods headquarters.

The Cornell Campus Store

Barnes Hall

Systems Development and The Ramo-Wooldridge Corporation

The Ramo-Wooldridge Corporation (except for the specialized activities of our subsidiary, Pacific Semiconductors, Incorporated) is engaged primarily in developing—and will soon start to manufacture—systems rather than components. For military customers our weapons systems responsibilities are in the fields of guided missiles, fire control, communications, and computers. Our non-military systems activities are in the general area of automation and data-processing.

Emphasis on systems development has consequences that profoundly affect all aspects of an organization. First, it demands an unusual variety of scientific and engineering talent. A single systems development project often requires concurrent solutions of challenging problems in the fields of electronics, aerodynamics, propulsion, random phenomena, structures, and analytic mechanics. In addition, the purely technical aspects of a systems problem are often associated with equally important non-technical problems of operational, tactical, or human relations character.

Therefore, competent systems development requires that a company contain an unusually large proportion of mature, experienced scientists and engineers who have

a wide range of technical understanding and an unusual breadth of judgment. Further, all aspects of company operations must be designed so as to maximize the effectiveness of these key men, not only in the conduct of development work but in the choice of projects as well.

At Ramo-Wooldridge we are engaged in building such a company. Today our staff of professional scientists and engineers comprises 40% of the entire organization. Of these men, 40% possess Ph.D. degrees and another 30% possess M.S. degrees. The average experience of this group, past the B.S. degree, is more than eleven years.

We believe the continuing rapid growth of our professional staff is due, in part, to the desire of scientists and engineers to associate with a large group of their contemporaries possessing a wide variety of specialties and backgrounds. It is also an indication that such professional men feel that the Ramo-Wooldridge approach to systems development is an appropriate one.

We plan to continue to maintain the environmental and organizational conditions that scientists and engineers find conducive to effective systems development. It is on these factors that we base our expectation of considerable further company growth.

POSITIONS ARE AVAILABLE FOR
SCIENTISTS AND ENGINEERS IN
THESE FIELDS OF CURRENT
ACTIVITY:

Guided Missile Research and Development
Digital Computer Research and Development
Business Data Systems Development
Radar and Control Systems Development
Communication Systems Development

The Ramo-Wooldridge Corporation

8820 BELLANCA AVENUE, LOS ANGELES 45, CALIFORNIA



to the well too often

There are easier ways to get a drink.

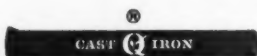
And engineering graduates will be called upon to develop them. They'll have to help supply and distribute the billions of gallons of water needed daily by homes and industry. Water that will be increasingly hard to find.

But when they find it, they can rely on cast iron pipe to carry it. Practically every city in America — large or small — uses it for water and gas mains. In over 60 of them cast iron pipe has served for a century or more.

No other pipe can point to such a long and useful record of service to the nation.

CAST IRON PIPE RESEARCH ASSOCIATION

Thos. F. Wolfe, Managing Director, 122 So. Michigan Avenue, Chicago 3, Ill.



CAST IRON PIPE SERVES FOR CENTURIES

College News

A method of detecting the location of the jet stream, a high velocity "river" of air found far above the earth's surface, is being studied by scientists at the Cornell Aeronautical Laboratory, Inc.

Efficient detection would permit commercial and military airplanes to take greater advantage of the winds up to 200 miles per hour. By using the stream as a tail wind, tremendous savings in flight time and fuel consumption of aircraft could be achieved.

Jet streams are found at altitudes of 25,000 to 40,000 feet. In the northern hemisphere, these invisible winds run roughly west to east, sometimes encircling the earth.

Present detection methods, which include flying into the stream or use of some meteorological techniques, are generally inadequate. An airplane's pilot would not necessarily know he had flown into a jet stream even though he encountered rough air in the process. The pilot would need either to track the ground or be tracked from the ground by radar in order to establish the difference between his airspeed and ground speed. Some navigational position devices are useful but require the airplane to remain in the stream for some time in order to establish true velocity.

The Laboratory's Physics Department, in a contract for the U. S. Navy, has started the project. The first phase of the program calls for the instrumentation of aircraft with equipment to measure electrostatic phenomena, in accordance with the suggestion by other experimenters that the jet stream carries a net electrical charge. The argument was made that an electrostatic field appears at the earth's surface when a jet stream axis is within 150 to 200 miles of the observing station. C.A.L. scientists believe that the existence of electrification in the jet stream is plausible but has not been proven. Flights in or near the stream by an airplane carrying instruments for measuring

an electric field should serve to verify or disprove the possible electrification.

Since its "discovery" in the early 1940's, the jet stream has been the subject of concentrated scientific investigation, and, in many circles, controversy. Most of the information gathered thus far relates to its origin and identity. The exact momentary location of the stream is usually not known since a considerable time delay is associated with gathering and analyzing data connected with it.

Wind Tunnel Tests, Erosion Studies

The Cornell Aeronautical Laboratory, of Buffalo, N. Y. has announced that it is currently undertaking the study and testing of two more important engineering problems—the erosion by rain and hail of exterior surfaces of high speed aircraft, and the complete and accurate engineering data on the U. S. Navy's latest supersonic fighter, the Grumman F9F-9 Tiger.

The erosion, or wearing away, of plastic and aluminum structures—a onetime threat to the nation's all-weather defense program—particularly effects the leading edges of the aircraft.

The Laboratory has been one of the leading investigators of this facet of rain erosion for six years and in cooperation with the U. S. Air Force and a number of industrial and research centers has been attempting to obtain information that would lead to an understanding of the nature and mechanism of the erosion process.

The problem was first observed by the Air Force in 1945 when rain striking the leading edge of a radar housing on a high speed plane caused rapid deterioration of the plastic part.

Although progress has been made in the development of elastomeric coatings which greatly reduce erosion,

the fundamental mechanism of erosion has not been solved and research will continue. Commercial firms are now providing rubber-like coatings which give 1½ hours erosion resistance at speeds of 500 miles per hour as tested on the Air Force Laboratory rain erosion test apparatus operated and located at the Cornell Aeronautical Laboratory.

Early studies at the Cornell Laboratory showed that the paints and plastics evaluated had a very short life, generally in the range of one to two minutes at 500 miles per hour in rain. The effect of droplet size, velocity, and angle of impact on paints, metals and plastics was investigated.

As evidence of the increase of erosion with velocity, it was found that a specimen that underwent testing at 500 mph in a special rain cell showed effects of erosion in only one minute, while a similar specimen run at 200 mph required 24 hours of testing before erosion began to show.

The Air Force has reported that the severity of rain erosion has been indicated by the failure of antenna masts, radar housing, and similar non-structural components. Early recognition of the problem and methods that were developed to reduce the effect of erosion have helped maintain this safety record.

Materials Department personnel at Cornell Laboratory have, under the guidance of Dr. Philip K. Porter, experimented with nearly 3,000 materials of plastic and elastomeric nature.

For the investigation, a special cell was erected where simulated rainfall could be produced. A propeller-type blade, which would be rotated up to speeds of 760 miles per hour in the rain, was used to evaluate materials for rain erosion resistance. Specimens were mounted on the leading edge of the blades.

Slow motion pictures of specimens attached to the blade's leading edge moving at velocities of 500 mph showed that the raindrops,

upon impact, splattered into thousands of tiny particles, an effect, when multiplied by hundreds of raindrops, that caused pitting and wear.

Of the large number of materials evaluated, elastomeric or rubber coating systems were the most satisfactory. These materials were also evaluated for such properties as adhesion, outdoor durability, resistance to water and service fluids, and effects of temperatures from -65 degrees to 400 degrees.

Even though the Grumman Tiger was flown for the first time last summer, wind tunnel tests are still being continued by the Cornell Laboratory so that more accurate engineering data on the ship's performance can be acquired.

The Tiger was designed by Grumman around the Navy's concept of a powerful carrier striking force and can carry the most modern armament, including air-to-air and air-to-ground missiles.

More than 150 hours of test time have already been logged in the variable density wind tunnel and all of it is in the transonic speed range.

The Laboratory-developed a 3 x 4 foot transonic throat, which can be inserted in the 8½ x 12 foot tunnel test section, has been used for the testing. The throat is of the perforated wall type construction that minimizes the usual reflection of shock waves onto the model by the tunnel walls. The walls, being "porous-like," act to cancel out these reflected waves, which can interfere with the accurate collection of data on the model.

Cornell's wind tunnel is one of the busiest and most versatile in the nation, performing more than 3,000 hours of testing for the military services and aircraft industry during the last year. Nearly half of this testing was in the vital transonic speed range.

Industry Grants for Education

Cornell University is one of the 150 or so colleges of the country which will receive financial aid from the various industries of our Nation. Recognizing that the future of the nation may well be in the

hands of such institutions of higher learning as Cornell University, U. S. industry has adopted a new attitude toward higher education. The recent announcement by General Motors that they have created a \$2,000,000 a year gift program has highlighted the recent developments in the program. Other companies with the program they have, or will sponsor, follow:

Ford Motor Co. finances about 70 scholarships a year for the sons and daughters of employees and also gives \$500 annually to each private college or university the students happen to choose.

The Gulf, Mobile & Ohio Railroad has given more than \$185,000 since 1951 to private colleges along its route.

DuPont now pours \$2,500 grants into the chemistry departments of 50 different campuses, and expects to give in various ways \$800,000 this year.

The Radio Corp. of America will pay for 26 scholarships (at \$800) this year.

Standard Oil Co. (N. J.) spread \$450,000 over 138 campuses plus \$50,000 for the National Fund for Medical Education last year.

Union Carbide's plan: \$50,000 for 400 scholarships to more than 30 colleges.

Standard Oil Co. (Ind.) gave more than \$350,000 in 1954, and matches its scholarships with equal gifts to each campus.

U. S. Steel last year gave \$700,000 in unrestricted gifts.

Bethlehem Steel since 1953 has given \$321,000 to the colleges—if privately endowed—of young employees completing its collegiate training program.

The Columbia Broadcasting System is giving \$32,000 to the alumnates of its own selected executives.

General Electric has promised to match every employee's gift to his own college up to \$1,000, and will spend "substantially more" than \$1,000,000 in 1955.

Speaking Contest Winners

Thomas H. Arnott, a fifth-year student in mechanical engineering

at Cornell, has won first prize of \$25 in a public speaking contest held by the Cornell student branch of the American Society of Mechanical Engineers. His paper was on "Automobile Air Conditioning Control Systems."

Barry Kolton, also a fifth-year student in the school, won second prize of \$15 for a paper on "The Flying Saucer Paradox." David Narins, a fourth-year student, won third prize of \$10, discussing "The Use of Models in Modern Engineering Practice." The contest took place Thursday (March 17) at Cornell.

Mr. Arnott will represent Cornell in a similar contest during the ASME region three conference at Johns Hopkins from April 23-30, where he will compete with students from 18 other schools in New York, Maryland, Pennsylvania, Delaware and the District of Columbia. He is a son of Mrs. Pauline Pruden, 3 Harvey Court, Baldwin, N. Y., and a graduate of Hempstead High School.

Mr. Kolton is a son of Mr. and Mrs. Heyman Kolton, 477 Leslie Street, Newark, N. J., and a graduate of Weequahic High School.

Mr. Narins is a son of Mr. and Mrs. Samuel Narins, 22 Willow Road, Woodmere, N. Y., and a graduate of Woodmere High School.

AIEE Contest Winners

Three Cornell students—Leonard A. Mende, Edward F. Sutherland and Edmund G. Rynaski — have won prizes of \$25, \$15 and \$10, respectively, for papers presented in a contest sponsored by the Ithaca section of the American Institute of Electrical Engineers.

All three are fifth-year students in the School of Electrical Engineering at Cornell, and Mr. Mende is double - registered in the Cornell Law School.

Prof. M. G. Malti of the school was in charge of the contest, the finals of which took place Friday (March 18) in Binghamton, N. Y.

Mr. Mende, son of Mr. and Mrs. William Mende of 523 Park Avenue, Albany, discussed "What Every Engineer Should Know About Patent Law." By placing first in

THE CORNELL ENGINEER

"NEW DEPARTURES" IN SCIENCE & INVENTION



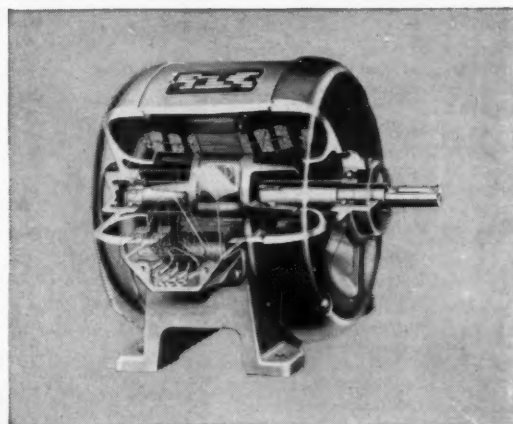
NIKOLA TESLA, THE MAN WHO HARNESSED NIAGARA

Water, water, everywhere — and no power. That was Niagara Falls when Nikola Tesla began work on its power system in 1888. Now Niagara is one of the world's largest electric power plants.

But to make the most of this power, many problems in electric motor design had to be overcome. New Departure ball bearings have helped solve many of them. For example, motors with New Departure self-sealed ball bearings may be mounted in difficult-to-reach locations because the bearings will operate for years without attention for relubrication or adjustments of any kind.

Highly important also are the facts that these ball bearings resist loads from all directions and, being grease-lubricated, permit motors to be applied in any position from horizontal to vertical without loss of efficiency or trouble from lubricant leakage. Whatever the loads, New Departure ball bearings maintain accurate rotor-to-stator relationship — are cool-running at all motor speeds.

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT



New Departure ball bearings assure positive rotor support under all loads in this motor. Bearing seals, pioneered by New Departure, keep lubricant out of the motor. Shields on the reservoir side keep foreign matter out of the bearings.





A Tower of Opportunity

for America's young engineers with capacity for continuing achievements in radio and electronics


Today, engineers and physicists are looking at tomorrow from the top of this tower... the famed Microwave Tower of Federal Telecommunication Laboratories... a great development unit of the world-wide, American-owned International Telephone and Telegraph Corporation.

Here, too, is opportunity for the young graduate engineers of America... opportunity to be associated with leaders in the electronic field... to work with the finest facilities... to win recognition... to achieve advancement commensurate with capacity.

Learn more about this noted Tower of Opportunity... its long-range program and generous employee benefits. See your Placement Officer today for further information about FTL.

INTERESTING ASSIGNMENTS IN—

Radio Communication Systems
Electron Tubes
Microwave Components
Electronic Countermeasures
Air Navigation Systems
Missile Guidance
Transistors and other Semiconductor Devices
Rectifiers • Computers • Antennas
Telephone and Wire Transmission Systems

**Federal
Telecommunication
Laboratories** 

A Division of International
Telephone and Telegraph Corporation
500 Washington Avenue, Nutley, N. J.

this contest, he is eligible to represent the section in a northeastern district contest to be held at Cornell on April 28.

The second prize went to Mr. Sutherland for his paper on "A Sound Track for the Home Movie Camera." He is a son of Mrs. C. W. Sutherland, 94 Otis St., Hingham, Mass.

Mr. Rynaski, son of Mrs. Frances Rynaski of 613 North Colony St., Meriden, Conn., discussed "A Servo-mechanism X-Y Recorder."

Cyclonite

(Continued from page 21)

cyclonite have important application in one of the most interesting developments in explosives to come out of the last war; the so-called "plastic explosives" or "explosive putties." These were soft, plastic, somewhat sticky mixtures of cyclonite and a binder, used in demolition operations. A gob of the stuff could be plastered on anything one wanted to cut or pierce, such as a bridge girder, tank, or pillbox, and the charge detonated. The ensuing very brisant explosion would shatter the object more effectively than other forms of demolition.

The earliest such mixture, known as "RDX Composition C," was essentially a mixture of 88 parts finely divided cyclonite and 12 parts lubricating oil. This was superseded by Composition C-2 and then Composition C-3. This last explosive is composed of 78 percent cyclonite and 22 percent resinous binder of nitrated aromatic hydrocarbons and nitrocellulose. The binder is also explosive, and C-3 has a better cutting action on

steel plate than either Composition C or C-2. In the Joint Army-Navy specifications for Composition C-3, a one-inch cylinder of the explosive weighing 20 grams is required to perforate a 1/4 inch mild steel plate placed flat against the end of the cylinder.

Future Use Of Cyclonite

By and large, because of its cost, cyclonite will remain a military explosive, although some blasting caps and "primacord" (explosive rope) for civilian use are now being loaded with it. And since the demand for widespread destruction in military operations is more efficiently met by nuclear devices, it is possible that the world may never again see cyclonite and similar explosives produced on as large a scale as in the Second World War.

Though hardly classified as a "better thing for better living," the colorful history and unusual properties of this once strategic compound make it now one of the more interesting footnotes in organic chemistry.

BIBLIOGRAPHY

- Kirk and Othmer (editors), *Encyclopedia of Chemical Technology*, Vol. 6, pp 19-60. Interscience Encyclopedia, Inc. (1951)
- Davis, Tenny L., *Chemistry of Powder and Explosives*, pp 396-399. John Wiley & Sons, Inc. (1950)
- JAN-C-427: Joint Army-Navy Specification, Composition C-3. 12 December 1946
- Simmons, W. H., Forster, A., and Bowden, R. C., *The Manufacture of RDX in Great Britain*, Ind. Chemist. Vol. 24, pp 429-32, 593-601 (1948)
- Bachmann, W. E., and Sheehan, John C., *A new method of Preparing the High Explosive RDX*, J. Am. Chem. Soc., Vol. 71, 1842-5 (1949)
- Wright, Geo. F., Richmond, Henry H., and Downing, Douglas C., *Cyclonite*, U.S. pat 2,434,879. January 29, 1948

A Demolition Block M-3, containing about 2.2 pounds of RDX Composition C-3. In the foreground is a piece of the block, which resembles laundry soap.





Long-Range Development Program Provides for New Engineering Test and Research Facilities

● Allison's \$75 million expansion program in ENGINEERING, RESEARCH and DEVELOPMENT facilities creates the need for a 40 per cent increase in our engineering staff.

Completion of the five-year program—financed by General Motors—will give Allison, and Indianapolis, one of the world's most complete, best equipped, centers for the development of new, high performance turbo-prop and turbo-jet aircraft engines for both military and commercial use.

As General Motors President Harlow H. Curtice said in the announcement, "Engines in production today cannot meet the requirements of the aircraft of tomorrow where ability to operate at supersonic speeds, and very high altitudes, will continue to be demanded from engine builders . . . To design and build engines with such advanced performance, test

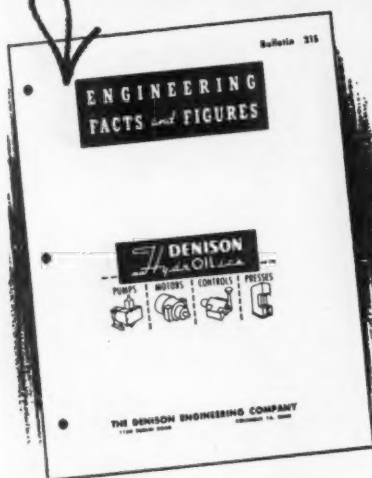
facilities are required which go far beyond the capabilities of equipment in existence today. In recognition of this need, General Motors will add extensive high performance test facilities to those already established and in operation at the Allison Division."

Already a recognized leader in the design, development and production of turbo-jet and turbo-prop engines, Allison NOW is in a position to offer even greater opportunities to the technically-trained, well-qualified, young graduate who is interested in building his engineering career with a pace setter in the field.

Whether you're still in school, or graduating this year, we'd like to tell you more about your engineering future at Allison. Write to:

R. G. GREENWOOD, Engineering College Contact
ALLISON DIVISION, General Motors Corporation
Indianapolis 6, Indiana.

Free facts and figures for engineers



Denison's Bulletin 215 is a working tool for engineers. There are no photos, no descriptions of products . . . just facts and figures you can use in your work.

Here is some of the information you'll find in this bulletin:

- Gallons converted into cubic inches
- Capacities of hydraulic rams in tons . . . based on diameter of ram and pressure
- Circumferences and areas of circles with given diameters
- Decimal equivalents of diameters
- Specific gravities and weights of various metals, alloys, solids and timber
- Squares and cubes of numbers from $\frac{1}{32}$ through $11\frac{1}{4}$

We have been using Bulletin 215 for distribution to our customers. If you'd like a free copy, write us.

THE
DENISON ENGINEERING COMPANY
1216 Dublin Road, Columbus 16, Ohio



Steel

(Continued from page 16)

mixed with approximately six per cent minus one eighth inch carbon in the form of coke breeze or anthracite fines. A bed of mixture is fed onto a moving grate which has a suction applied beneath it, causing a downdraft through the charged mixture. The mixture is ignited on the top of the bed and the carbon burns progressively down through the bed, fusing metallic particles together into a porous open celled structure called sinter.

Pelletizing

Concentrates are fed into a horizontal revolving drum which rolls them up into balls approximately one half inch in diameter. These are then heated to a temperature below the actual fusing temperature but high enough to cause cementing to take place. There are two different methods being tried for this heating. One is the shaft furnace in which the pellets are fed in at the top, fired about one fourth of the distance down and then allowed to cool for the balance of their journey to the bottom of the furnace where they are withdrawn. In the second method the green pellets are charged onto a traveling grate similar to a sintering grate. In this process they are dried, preheated, baked, and cooled in successive steps on the grate. The experiments on all of these processes are now being carried on in production size pilot plants. On one of these processes very likely hangs the future of the steel industry of the United States.

Lightning

(Continued from page 12)

feed enough charge to the leader to keep the electric field intensity at its tip greater than the air's breakdown voltage, it will continue to descend, and may or may not branch out. All the time it is leaving behind a conducting channel of ionized air which will provide a path for the return stroke.

As the leader nears the earth's surface it causes an increasing field intensity to appear there which may be sufficient to start lightning streamers upward perhaps to a height of fifty feet. This does not always happen, but it is likely to when tall trees or buildings are present to provide points where the

earth's charge can concentrate. Although this condition is logically necessary, it did not hold in Fig. 3, demonstrating lightning's capricious nature.

The meeting of an upward streamer and a downward leader initiates the return stroke. It follows the ionized path of the leaders, extending down their branches as it comes to them, and continues to flow after contact with the cloud charge center until the charge is neutralized.

Charge Centers Cause Multiple Strokes

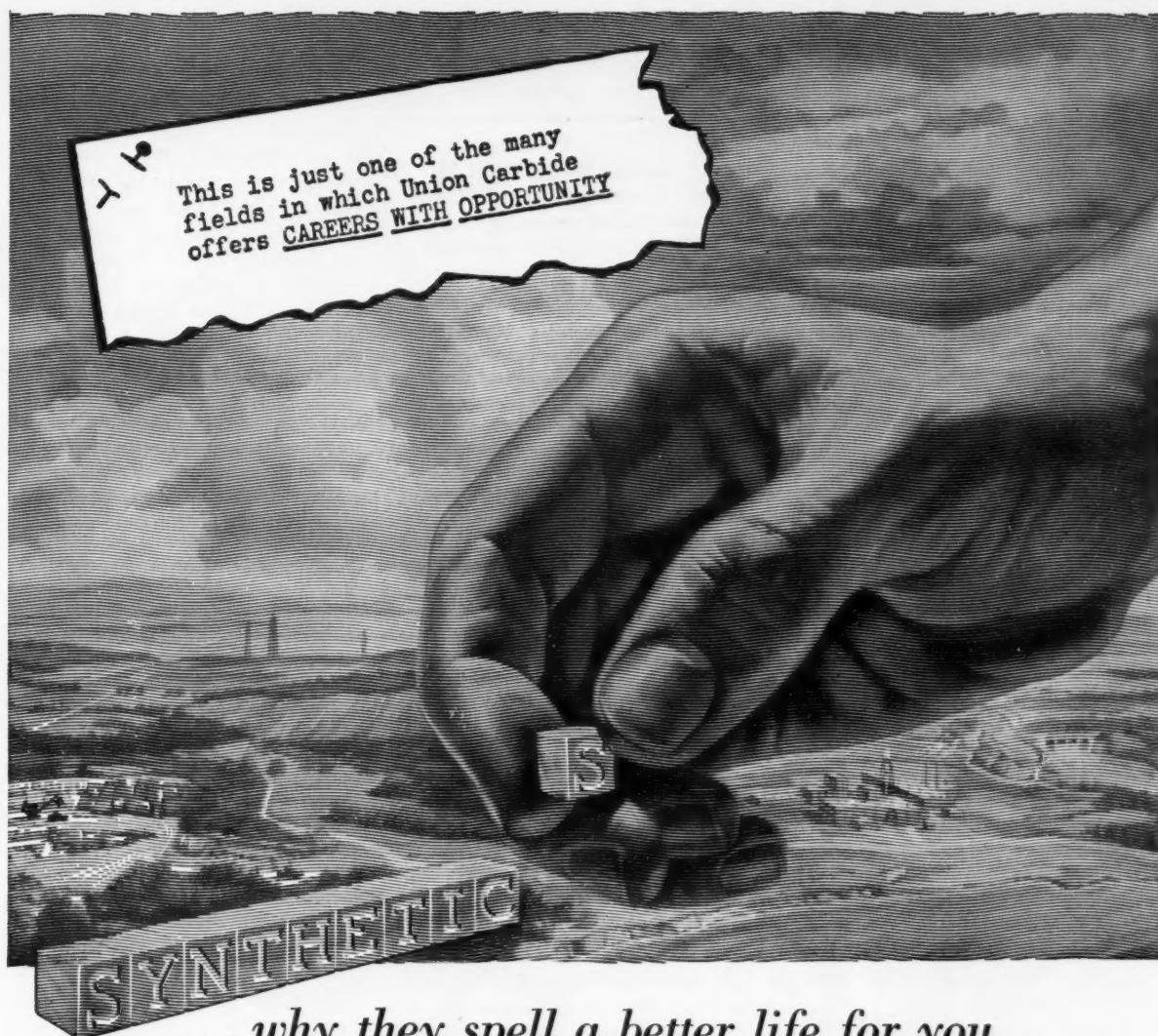
Mention was made earlier of the actual complexity of a cloud. This is important because it may result in multiple instead of single strokes. A multiple stroke is a series of discharges called components traveling in rapid succession down the same path, each discharging a different charge center. The presence of adjacent charge centers drives the process; when one is neutralized a streamer goes from it to another one, connecting the second center to the ionized channel which leads to the earth and starting a second stroke.

A component has a leader and a return part, but the leader differs from the pilot or stepped types in that its motion is continuous in previously ionized air—it is called a dart leader. Even if the path is blown aside by high winds the components follow it faithfully. As many as forty components have been recorded in one multiple stroke. An oscillogram of the current of one of these strokes would show a number of current peaks superimposed on a low "continuing current," which is often too small to be recorded (below 20 amp.—see Fig. 4). The time which elapses during all these processes is very small—a single stroke is about half a second. Peak currents of over 200,000 amperes have been known to flow, but the usual value is on the order of tens of thousands of amperes. The smaller values measured at the Empire State Building probably indicate the influence of the building's height.

"Hot," "Cold" Lightning Contrasted

Another aspect of lightning is its current waveform, two types being recognized on this basis. There are

(Continued on page 57)



This is just one of the many fields in which Union Carbide offers CAREERS WITH OPPORTUNITY

... why they spell a better life for you

A CENTURY AGO, pioneering scientists learned to take apart water, air, and earth and put them together again ... in completely different arrangements.

THE RESULT, very often, was a *synthetic*—a brand new material that didn't exist in nature, or a more abundant, more useful version of a nature-made product. Thus, through the years, synthetic has come to mean 'man-made and well-made.'

Science has developed nearly half a million synthetic materials since that time, and millions more are possible.

WHERE DO SYNTHETICS fit into your life? Nearly everywhere! The aspirin you take for a headache, the life-saving sulfa drugs and scores of other modern medicines are synthetics. So are today's remarkable plastics, new textiles, and many paints, dyes, adhesives, and valuable chemicals.

AN IMPORTANT PART of the work of the people of Union Carbide is discovering and producing synthetic materials that serve you and industry. From natural gas and oil, alone, they produce nearly 400 chemicals. Among them are chemicals that are vital to everything from synthetic rubber to cosmetics ... and to the variety of plastics and resins made by UCC, which are used in nearly every home and industry today.

STUDENTS AND STUDENT ADVISERS: Learn more about career opportunities with Union Carbide in *ALLOYS, CARBONS, CHEMICALS, GASES, and PLASTICS*. Write for booklet C-2.

UNION CARBIDE AND CARBON CORPORATION

30 EAST 42ND STREET **UCC** NEW YORK 17, N. Y.

In Canada: UNION CARBIDE CANADA LIMITED

UCC's Trade-marked Products include

SYNTHETIC ORGANIC CHEMICALS	PRESTONE Anti-Freeze	EVEREADY Flashlights and Batteries	PREST-O-LITE Acetylene
Dynel Textile Fibers	ELECTROMET Alloys and Metals	HAYNES STELLITE Alloys	UNION CARBIDE
LINDE Silicones	BAKELITE, VINYLITE, and KRENE Plastics	NATIONAL Carbons	ACHESON Electrodes
			LYNDE Oxygen
			PYROFAX Gas

Technibriefs

Every day could be wash day somewhere on the railroads if a revolutionary new theory recently conceived proves economically feasible:

The theory points to washing rails—with a detergent possibly—to help eliminate one of the railroads' oldest and most expensive problems—slipping of locomotive wheels.

The new theory holds that slipping is caused by an extremely thin, practically invisible layer of oil approximately one molecule thick, which spreads itself over the running band of a rail at the onset of rain or when there is dew. Despite its thinness, this "monomolecular layer" can withstand pressures so high (up to 75,000 pounds per square inch) that locomotive wheel loads ordinarily used will not break through it.

At many places on railroad track, accumulations of journal oil can be observed outside the wear band. When the rails become moist or damp, the oil spreads over the rail, pushing the water off. The result is a thin film of oil which causes slipping, and often stalls crack trains traveling on grades.

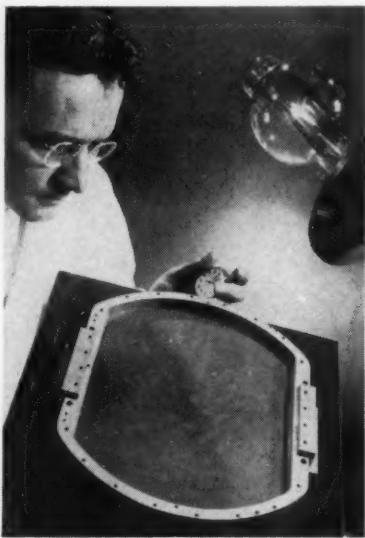
Journal oil, used in the bearings of freight cars, contains some percentage of animal oils which spread rapidly over a polished surface in the presence of a small amount of water. Oxidized mineral oils seem to exhibit the same characteristics as animal oils or fish oils and spread over a polished surface in the presence of moisture.

One drop of oil in the presence of moisture has the ability to cover a surface of five square meters. If tracks were not interrupted by rail joints, this one drop would spread along the polished running part of the rail ($\frac{5}{8}$ inch wide) to form a slippery film for a distance of two miles.

It is felt that if the source from which the film spreads is removed, the presence of moisture will no longer cause slipping.

Cleaning methods now under investigation, in addition to water, include detergents, solvents, open

flame, and ultraviolet light. If a suitable cleansing agent is found, much of the sand currently used on locomotives to improve traction on wet days can be eliminated, with the added benefit of a reduction in the drag of the train.



Color TV Tube.

Photographic Method Forms Color TV Screen

In a color television picture tube screen, three different phosphor materials may be placed in an interspersed dot pattern on a glass plate, a phosphor for each of three primary colors, red, blue, and green. An engineer at Sylvania Research Laboratories uses a photographic method of forming the complex screen. Light from the point source zirconium lamp passes through an aperture plate containing more than 200,000 precisely spaced small holes. Rays of light fall in the desired dot pattern on a photographic emulsion containing the color phosphor. After controlled exposure and processing, only the phosphor remains in the pattern. The process is repeated for the other two phosphors with the screen and aperture plate moved slightly to permit the new dots to fall between those previously formed. A full color picture is produced by each of three electron streams being made to fall on the appropriate set of color phosphor dots.

Automatic Production Of Electronic Circuits

An automatic system to place components in varied types of electronic equipment sub-assemblies will be a step toward the automatic factory. The system, with flexibility to switch rapidly from one type of assembly operation to another, is being built by General Electric for the Army Signal Corps as an industrial preparedness measure.

Unlike automatic assembly systems for long-run, standardized operations, the new system can adapt itself immediately to work on varied sizes of circuit boards, using different types and sizes of components with up to eight leads each.

The significance of such a flexible system is said to stem from the fact that the majority of electronic equipment business, dollarwise for both commercial and military use, is measured in the thousands of units rather than in the tens of thousands for such entertainment equipments as home radios and TV sets.

The new system has an electronic reader, which sets up production steps from punch cards. When a different job is to be done, the reader is fed the punch card for the job. It then sets up the system to prepare and test components, convey them to the assembly unit, assemble them, and test the completed sub-assembly.

The system can be programmed to place any number of components, limited only by the size of the circuit boards and the size of components themselves, and will be capable of placing as many as 1,600 components per hour. All the placement operations are done by one placement unit; in contrast, the mass-production type assembly systems place one component at each unit, and require as many placement units as there are components to be placed. Attendants are needed only to load circuit boards and components, and to check operation of the system at a central control console. This new step towards automatic production follows the automatic punch press announced last January, which was similarly controlled by a punch card "reader" and featured a similar degree of flexibility.



Only a few short years ago

the helicopter was thought to be a "stunt" machine — amazing and amusing, and not particularly important. Events in Korea changed that idea — fast! This fledgling among aircraft performed "impossible" military assignments, spectacularly successful missions of mercy. Helicopters came into their own.



Now in demand for hundreds of jobs, today's most versatile flying machine is the product of ceaseless testing, highest-calibre engineering, work and imagination.

You might find — in Sikorsky Aircraft's research departments, drafting rooms, engineering laboratories — a lifetime opportunity in this young, growing and most interesting field of aviation. Consult your College Placement Office concerning arrangements for a personal interview.



In 1939, the VS-300 with Igor Sikorsky at the controls made the first practical helicopter flight in the United States. Hundreds of later Sikorsky's were delivered for service in World War II.



Future Sikorsky's will be built by tomorrow's engineers. Perhaps *you* belong at Sikorsky where your skill and ability will be continually challenged.



SIKORSKY

Sikorsky Aircraft, one of the divisions of United Aircraft Corporation, South Avenue, Bridgeport 1, Conn.



NEW PRODUCT in the air conditioning field is Worthington's ultra-modern winter and summer home air conditioner. It's a compact package that heats, cools, circulates, filters, and con-

trols humidity. Like every Worthington product, this good-looking unit is designed and built for a lifetime of quiet, efficient service.

Making today's BIG news in air conditioning



NEW BUILDING in New York is the glass-sheathed Manufacturer's Trust Building. It's cooled by a Worthington central station system—so big it does the same job as melting 300 tons of ice daily.



NEW LIFE FOR OLD STORES. Shoppers stay longer, buy more in stores cooled by Worthington units with the new "Million Dollar" compressor. New 3-D circulation aims comfort right where you want it.

Worthington's new residential air conditioners, packaged units, big central station systems—all are making headlines in the air conditioning field. And the same research and engineering skills responsible for their development are applied to all Worthington products—engines, turbines, compressors, construction machinery, as well as pumps.

For the complete story of how you can fit into the Worthington picture, write F. F. Thompson, Mgr., Personnel & Training, Worthington Corporation, Harrison, New Jersey.

4.25D

See the Worthington representative when he visits your campus

See the Worthington Corporation exhibit in New York City. A lively, informative display of product developments for industry, business and the home. Park Avenue and 40th Street.

WORTHINGTON



When you're thinking of a good job—think high—think Worthington

AIR CONDITIONING AND REFRIGERATION • COMPRESSORS • CONSTRUCTION EQUIPMENT • ENGINES • DEARATORS • INDUSTRIAL MIXERS
LIQUID METERS • MECHANICAL POWER TRANSMISSION • PUMPS • STEAM CONDENSERS • STEAM-JET EJECTORS • STEAM TURBINES • WELDING POSITIONERS

Lightning

(Continued from page 52)

hot lightning, which has a low current and long duration, and cold lightning which is known by a high peak of very short duration.

The terms "hot" and "cold" are derived from the physical damage each type causes. Hot lightning will start a fire, but it will not produce the shattering effect of cold, and vice versa. The difference is due to the failure to reach the ignition temperature of inflammable materials in the short time period of cold lightning. But the cold strokes will, however, perform such stunts as vaporizing a copper wire, making it vanish, without harming the insulation which surrounded it. An interesting historical note was provided by Pliny the Elder, a Roman author, who included the following passage in his *A Natural History* in the first century A.D.:

"Of thunderbolts themselves several variations are reported. Those that come with a dry flash do not cause fire but an explosion. The smoky ones do not burn but blacken. There is a third sort called 'bright thunderbolts' of an extremely remarkable nature; this kind draws casks dry without damaging their lids and without leaving any trace and melts gold and silver in their bags without singeing the bags themselves at all and without melting the wax seal. Marcia, a lady of high station in Rome, was struck by lightning while with child and tho the child was killed, she herself survived without being otherwise injured. Among the portents in connection with Catiline, a town councilor of Pompeii named Marcus Herrenius was struck by lightning on a fine day."

Protection Methods Are Effective

Present lightning protection practices are quite effective due to a knowledge of the mechanism of the stroke. Electric power system protection is a broad subject which includes the use of electronic as well as electro-mechanical devices, but since this paper is mainly concerned with the stroke itself only that device will be discussed which depends directly on an understanding of the stroke. It is a form of Franklin's invention, the lightning rod.

The principle of operation of the lightning rod is that streamers start up from certain points on the earth when it is approached by the downward leader, and start the stroke by contacting the leader. It is ap-

parent that the first streamer to do this will be one from a high object, and the function of the lightning rod is to be that object. For a grounded, vertical mast there is an area known as the "cone of protection" which has its apex at the mast's tip and its circular base on the earth's surface around the mast. The diameter of the cone is roughly equal to the height of the mast; and the area enclosed by the base of the cone will have approximately 0.1% protection, meaning that 99.9% of the strokes to that area will either strike the mast or a point outside the cone of protection.

But in order to be effective, the lightning rod must be very well grounded; that is, the contact resistance between the rod and ground must be very small. If it is not, the large lightning currents flowing in the resistance will produce a huge voltage drop across it and the rod will then be at a high potential with respect to ground. When this happens, the stroke, after striking the mast, is likely to

jump to some other, easier path to ground and do a great deal of damage on the way. For this reason it is dangerous for a human to stand under a tree during a thunderstorm; the tree is a high resistance and a stroke trying to find ground may strike an upper branch and then jump to the ground through the person.

Ground Wires Protect Power Systems

The application of these principles to electric power systems is through ground wires—conductors which run parallel to and above the transmission lines, and electrically connected to their supporting towers. When the towers are well grounded, the ground wires provide a protective "tent" over the lines similar to the cone of protection of the single mast. The number of direct strokes to lines has been greatly reduced by this practice; before its introduction strokes fell on unshielded lines at an average rate of once per mile per year in regions where the frequency of

(Continued on page 60)



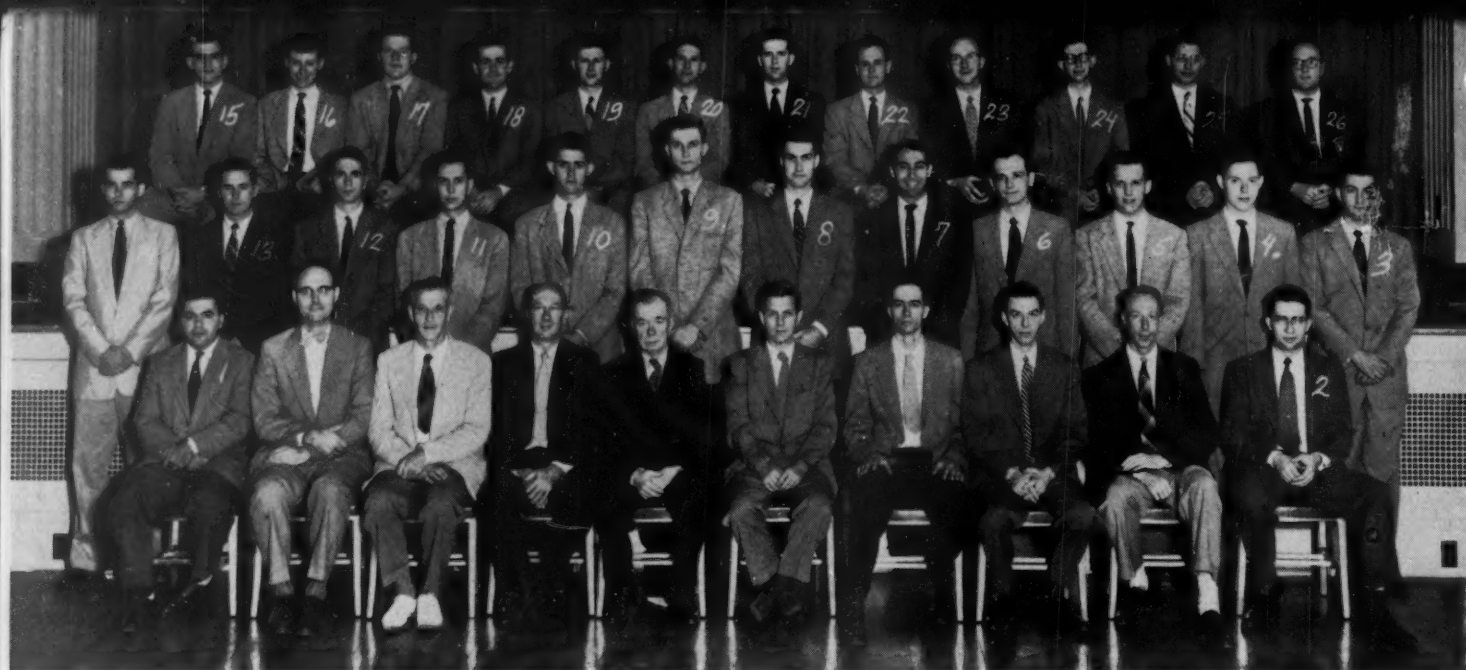
Performance...

A Key to K&E Leadership

Superb optics. Stability of adjustments. Dependable precision. Rugged construction. These are among the essentials built into K&E PARAGON® Surveying Instruments. These qualities combine to give the performance for which K&E PARAGON instruments are famous, through long years of service, under all conditions, in all climates. Performance is one of the keys to K&E leadership in drafting, reproduction, surveying and optical tooling equipment and materials, in slide rules and measuring tapes.

KEUFFEL & ESSER CO.

New York • Hoboken, N. J.
Chicago • St. Louis
Detroit • San Francisco • Los Angeles • Montreal



SCHOOL OF CHEMICAL ENGINEERING CLASS OF 1955

1. Leonelli, H. S.
2. Schmutz, J. F.
3. Lodico, R. E.
4. Kahn, R.
5. Verbsky, J. D.
6. Williams, R. H.
7. Griff, A. L.

8. Fischer, H. B.
9. Cramer, G. C. Jr.
10. Dawson, D. C.
11. Bugler, A. G. Jr.
12. Page, J. P.
13. Davis, R. L.

14. Wilson, J. A.
15. Polak, R. B.
16. Bishop, G. H.
17. Thurber, W. C.
18. Warden, M. R. Jr.
19. Harman, A. R. Jr.

20. Mensh, M.
21. Nerrow, D. J.
22. Campbell, R. T.
23. Davison, M. H.
24. Kaufman, I. A.
25. Mayer, R. J.
26. Rothfeld, L. B.

Not pictured: Manley, J. H.; McDowell, E. R. H.; Zinn, K. E.

SCHOOL OF ENGINEERING PHYSICS CLASS OF 1955

1. Jacobs, A. M.
2. Rathbun, H. M.
3. Sherry, M. E.
4. Lapp, M.
5. Jordan, N. P.
6. Klein, J. J.

7. Byron, S. R.
8. Mallison, J. A.
9. Edwards, H. H.
10. Hufnagel, R.
11. Mittag, L.
12. Orpett, E.

13. Brogan, T. R.
14. Stark, H. M.
15. Nguyen, C. H.
16. Joyce, W. B.
17. Finn, B. S.
18. Stevens, D. C.

19. Franco-Ferreira, E. A.
20. Cornish, R. H.
21. Deutsch, T. F.
22. Harwitz, R. B.

Not pictured: Lieb, D. P.





problem: gravity

Interested in it? So are we. For part of the advanced development program at Martin includes an overall search into the basic laws of the universe—probing the unknown in any field that relates to airborne systems.

Gravity is a personal problem to many creative engineers today: men who are lost in large engineering organizations; anchored to non-creative and futureless jobs. Ceiling Zero, Altitude Zero.

If you are one of those, you'd do well to look into the Martin story. For exciting new long-range developments have created many exceptional opportunities on projects of the highest priority and importance.

Contact J. M. Hollyday, Dept. CE-7, The Glenn L. Martin Company, Baltimore 3, Maryland.



FACTS THAT FIGURE in lower costs

FACT:

Steel is two to three times as strong as gray iron.

STEEL
Tensile strength
61,800 psi

GRAY IRON
Tensile strength
20 to 30,000 psi

FACT:

Steel is two and one half times more rigid than gray iron.

STEEL

GRAY IRON

FACT:

Steel costs only a third as much as gray iron.

STEEL

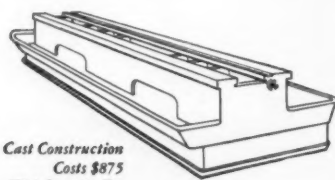
GRAY IRON

AND SO... by manufacturing your products from welded steel, costs can be reduced an average of 80%.

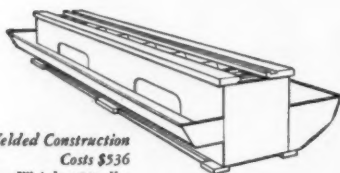
HOW PROPER DESIGN CAN LOWER COSTS

When you design properly for steel construction, your products will always cost less to manufacture. Because steel is two to three times stronger than cast iron, and 2½ times as rigid, fewer pounds of metal are needed. Also, each pound of material costs a third as much.

Here, for example, is a base for a machine tool. As a casting it would cost \$875 to build, weigh 4900 lbs. By proper design in steel, it costs only \$536. Although it weighs 2400 pounds less, the steel design is actually 45% more rigid to hold important alignment of the bed ways.



Cast Construction
Costs \$875
Weights 4900 lbs.



Welded Construction
Costs \$536
Weights 2500 lbs.

GET DESIGN HELP. Latest ideas on designing machinery for steel are in Lincoln Procedure Handbook on Arc Welded Design Practice. Write.

THE LINCOLN ELECTRIC COMPANY
Cleveland 17, Ohio

*The World's Largest Manufacturer
of Arc Welding Equipment*

Lightning

(Continued from page 57)

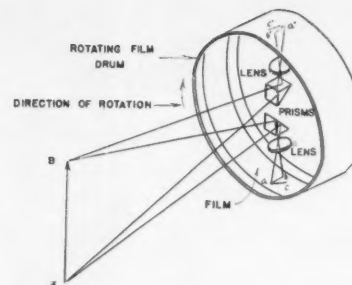
thunderstorms is not high.

To counterbalance their advantages, ground wires are expensive and the towers must be of heavy construction in order to support them. In locations where the frequency of storms or some other factor does not justify their use, protection is employed which acts after a stroke has struck the line and prevents power interruptions. Two such devices are lightning arrestors and expulsion tubes which allow grounding of the high currents but do not allow them to be followed by the normal line current. Another method is the use of a ground-fault neutralizer or Petersen coil which limits the value of fault current. A fourth protective technique is automatic reclosing; circuit breakers are used to disconnect the section of line where the fault occurs and immediately reconnect it, the process being repeated if the fault has not been cleared upon reclosing. In nearly all cases these measures allow a barely perceptible interruption of power.

Further Research Necessary

There are gaps in the knowledge of the habits of lightning which, if filled, would enable man to make it somewhat less a nuisance. One interesting problem is the effect of the earth on the location of the point of contact of lightning with ground and on whether the lightning will be hot or cold. The earth's influence is felt here in two ways—first is the effect of its resistivity on type and location, and second is the influence of physical features on meteorological factors relating to thunderstorms. Understanding of these might well make it possible to locate transmission lines so as to minimize the probability of a stroke.

Protection of individuals from lightning strokes probably interests everyone, and should be mentioned here before closing. The problem sounds simple — one must either stay out of the path of a stroke, or keep all parts of his body at the same potential. A good way to avoid a stroke in the home is to stay away from grounded or even large ungrounded metal objects, and refrain from handling electrical appliances. The statement has been



Schematic diagram of a High Speed Boys Camera.

made that a stroke will seek the easiest path to ground, and this is through a metallic conductor; hence the emphasis on the foregoing precaution. The safest location is inside a metal enclosure, grounded or not, such as a steel automobile—here is a case where the popular rumor is true.

The outdoors in general should be avoided during a storm. This is not because the walls of a house will in the least impede a lightning bolt, but standing near a point on the ground where a stroke falls may be fatal. When lightning enters the earth, large potentials and potential gradients appear in the earth's surface around the spot. Animals face greater danger from this cause; a voltage may appear between their fore and hind legs which is large enough to kill them.

There is really not much reason to restrict one's activities during a thunderstorm—a person's chance of being struck is on the average about one in 350,000. But, as McEachron points out, we are dealing with a possibility and not a probability. As for unpredictability, it has been shown that research has partially removed lightning from that realm and made use of new knowledge for the protection of life and property.

BIBLIOGRAPHY

1. Beck, Edward: *Lightning Protection for Electric Systems*, McGraw-Hill, New York, 1954.
2. *Electrical Transmission and Distribution Reference Book*, Westinghouse Electric and Manufacturing Company, First Edition, 1942.
3. Fay, Bernard: *Franklin, The Apostle of Modern Times*, Little, Brown and Company, 1929.
4. Lewis, W. W.: *The Protection of Transmission Systems Against Lightning*, John Wiley & Sons, New York, 1950.
5. McEachron, K. B. and Patrick: *Playing With Lightning*, Random House, New York, 1940.

TRIANGLE

ON THE SQUARE
T-SQUARES
SCALES
INKS
DRAWING BOARD

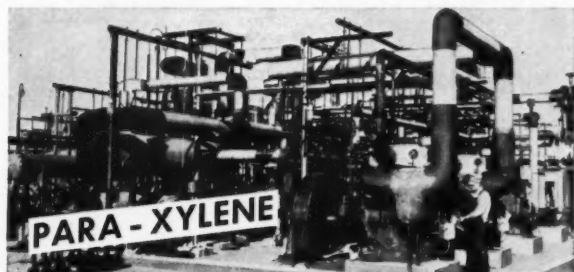
B
O
O
K
S
H
O
P

DRAWING PAPERS
SLIDE RULES
PROTRACTORS
GRAPH SHEETS
DRAWING SETS



Store Hours 8:15 A.M. to 7:45 P.M.
Monday through Friday
Saturday to 5:45 P.M.

Below Right: Three of the six Frick refrigerating machines in service at Big Spring, Texas.



New Phillips Product

New Application of Refrigeration

Phillips Chemical Company's new plant near Big Spring, Texas, is the first in the country to produce 98% pure para-xylene (used in the manufacture of a synthetic fiber) in commercial quantities.

The new, revolutionary process, patented by Phillips, involves continuous fractional crystallization. The heart of the system is a Frick "cascade" low-temperature refrigerating plant that FREEZES OUT para-xylene crystals.

Whether your process is in the idea, development or production stage—if it involves refrigeration or air conditioning, get in touch with your nearest Frick representative, or write directly to



The Frick Graduate Training Course in Refrigeration and Air Conditioning, operated over 30 years, offers a career in a growing industry.



This year, SKF needs just 9 engineering graduates for good, secure, important jobs.

Here's why these 9 will be lucky men . . .

They'll be with one of America's best-known and oldest manufacturers of ball and roller bearings—a medium-sized company where their work will be important to top management right from the start.

They'll be engaged in activities so basic they will be in contact with practically every industry.

They'll have a chance to get into sales, development or production engineering.

They'll have unsurpassed job security in good, friendly working conditions.

They'll have all the benefits they naturally expect—group insurance, retirement plan, paid vacations, good starting pay, frequent and fair salary reviews.

If you'd like to talk about being one of these lucky 9, the time to do it is *right now*. Waiting may well close the door to work so diversified you'll never tire of it, so basically important it's always secure. Why not fill in and mail the coupon today and let us tell you more?

7508

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.
—manufacturers of **SKF** and HESS-BRIGHT® bearings.

Mr. Ralph Palmer, Personnel Dep't.,
SKF Industries, Inc., Philadelphia 32, Pa.

YES, I'd like to know more about a good job as an SKF sales, development or production engineer. Send your literature to

Name


Address

School

City State

My degree will be





10,000,000 horsepower for America's defense . . .

Two years ago we announced the world's most powerful production aircraft engine.

Since then, the J-57 turbojet has been selected by many top airframe manufacturers to power their most outstanding new designs. For these fighters, bombers and transports, we have built over 1000 complete engines — the equivalent of more than 10,000,000 horsepower.

Today the J-57 is still unmatched anywhere — an important factor in this country's supremacy in the air.

PRATT & WHITNEY AIRCRAFT

Division of United Aircraft Corporation

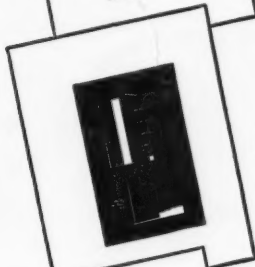
East Hartford 8, Connecticut

ALLOY STEELS PAY OFF		CLIMAX MOLYBDENUM COMPANY	
ALLOY	STEEL	ALLOY	STEEL
1	ALLOY STEEL	31	ALLOY STEEL
2	ALLOY STEEL	32	ALLOY STEEL
3	ALLOY STEEL	33	ALLOY STEEL
4	ALLOY STEEL	34	ALLOY STEEL
5	ALLOY STEEL	35	ALLOY STEEL
6	ALLOY STEEL	36	ALLOY STEEL
7	ALLOY STEEL	37	ALLOY STEEL
8	ALLOY STEEL	38	ALLOY STEEL
9	ALLOY STEEL	39	ALLOY STEEL
10	ALLOY STEEL	40	ALLOY STEEL
11	ALLOY STEEL	41	ALLOY STEEL
12	ALLOY STEEL	42	ALLOY STEEL
13	ALLOY STEEL	43	ALLOY STEEL
14	ALLOY STEEL	44	ALLOY STEEL
15	ALLOY STEEL	45	ALLOY STEEL
16	ALLOY STEEL	46	ALLOY STEEL
17	ALLOY STEEL	47	ALLOY STEEL
18	ALLOY STEEL	48	ALLOY STEEL
19	ALLOY STEEL	49	ALLOY STEEL
20	ALLOY STEEL	50	ALLOY STEEL
21	ALLOY STEEL	51	ALLOY STEEL
22	ALLOY STEEL	52	ALLOY STEEL
23	ALLOY STEEL	53	ALLOY STEEL
24	ALLOY STEEL	54	ALLOY STEEL
25	ALLOY STEEL	55	ALLOY STEEL
26	ALLOY STEEL	56	ALLOY STEEL
27	ALLOY STEEL	57	ALLOY STEEL
28	ALLOY STEEL	58	ALLOY STEEL
29	ALLOY STEEL	59	ALLOY STEEL
30	ALLOY STEEL	60	ALLOY STEEL

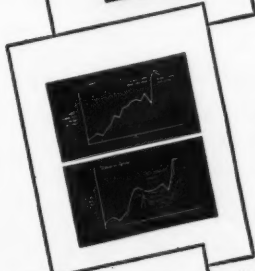


60 fully documented case histories

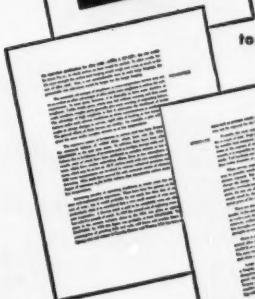
Facts on maximum pay load



Facts on lower operating costs



Facts on lower corrosion rate



Facts on toughness, wear, strength

CLIMAX MOLYBDENUM COMPANY, Dept. U
500 Fifth Avenue, New York 36, N. Y.

Please send me the 208-page handbook
"Alloy Steels Pay Off"

Name _____
University _____
School _____
Address _____

MAIL
THIS TODAY

If you're working for an
engineering degree, here's the
handbook you should have



This fact-packed handbook is a must if you are studying engineering. Here, with complete engineering data, you'll find how the use of alloy steels adds economies, increases service life, offers many other advantages.* It contains a valuable section on costs that you will

find most important because it spells out the economies of alloy steel. Design and metallurgical engineers now in industry have found the 60 case histories showing the advantages of alloy steels interesting and instructive. You will find this entire book to be an excellent reference for thesis projects and a valuable tool after you graduate. Send for your free copy. Climax Molybdenum Company, 500 Fifth Avenue, New York 36, New York.

MUS-19

* Advantages of ALLOY STEELS

- longer life
- greater pay load
- lower operating costs
- greater safety
- less maintenance

CLIMAX MOLYBDENUM

MAY, 1955

63

INDEX TO VOLUME 20

ARTICLES

	Number	Page
Aircraft Noises	1	18
Murray Kamrass		
Cavity Walls	2	11
Jerome Quinn, CE '57		
Cleaner Air on Demand	6	7
Peter Crimi, ME '58		
Cornell Aeronautical Laboratory— Workshop for the Future	2	18
Richard Brandenburg, EP '58		
Development	8	14
Equity and the Engineer	1	14
Sander L. Wise, CE '54		
Cornell: Pioneer in Dynamo Development	8	14
Richard Brandenburg, EP '58		
Cyclonite	8	18
C. V. Chester, Chem E '56		
Growth of the American Telegraph System	2	14
Howard P. Corwith, ME '16		
High Voltage Lab Expands	5	22
Richard Brandenburg, EP '58		
History of Steelmaking in America	7	18
Frank F. Walsh, Chem E '59		
Hydrazine	3	18
Felix J. Rosengarten, Chem E '57		
Ithaca, Center of Early Air Progress	6	12
Richard Brandenburg, EP '58		
Implications of Specialization	5	26
A. Robert Holtzapple, Arch '55		
Inspection of Telegraph Material	3	14
Bernard Pomerantz, ME '45		
Keeping up to Date on Atomic Energy—I	4	12
Keeping up to Date on Atomic Energy—II	5	12
Keeping up to Date on Atomic Energy—III	6	26
Stuart Braun, ME '57		

Prevention of Corrosion to Reserve Ships	5	7
Olive Bragg, ME '50		
Problems in Helicopter Design—I	3	9
Problems in Helicopter Design—II	4	16
Arthur H. Vaughan, EP '57		
Probing the Ionosphere	5	24
Richard Brandenburg, EP '58		
Senior Projects in the College of Engineering	5	18
Arthur H. Vaughan, EP '57		
Shell Molding	2	22
Stuart Braun, ME '57		
Steelmaking Processes	8	14
John M. Walsh, Chem E '59		
Technical Education— European Style	4	22
John F. Ahearne, EP '57		
Telephone Carrier Systems	7	12
John F. Ahearne, EP '57		
The Catalytic Cracking Process	4	9
John F. Schmutz, Chem E '55		
The Seismic Exploration for Oil	5	10
Thomas C. Reed, ME '56		
The Nature of Lightning	8	9
Leon Hall, EE '55		
The New ElectronSynchrotron	8	29
Thurston Hall Improvements	4	20
Richard Brandenburg, EP '58		
Transportation of Chemicals	1	9
Sachiyuki Masumoto, Chem E '54		
Morton Lowenthal, Chem E '54		
Very high Temperatures	7	7
Prof. Arthur Kantrowitz		
Why Choose Cornell?	6	40
(staff)		

AUTHORS

	Number	Page
Ahearne, John F.	4	22
	7	12
Bragg, Oliver	5	12
Brandenburg, Richard	2	18
	4	20
	5	22
	5	24
	6	12
	8	14
Braun, Stuart	2	22
	4	12
	5	12
	6	26
	8	18
Chester, C. V.	8	18
Corwith, Howard P.	2	14
Crimi, Peter	6	7
Hall, Leon	8	9

Holtzapple, A. Robert	5	26
Kamrass, Murray	1	18
Kantrowitz, Prof. Arthur	7	7
Lowenthal, Morton,	1	9
Masumoto, Sachiyuki	1	9
Pomerantz, Bernard	3	14
Quinn, Jerome	2	11
Reed, Thomas C.	5	10
Rosengarten, Felix J.	3	18
Schmutz, John F.	4	9
Vaughan, Arthur H.	3	9
	4	16
	5	18
	8	29
Walsh, Frank F.	7	18
Walsh, John M.	8	14
Wise, Sander L.	1	14

How good is this spot for a poster?

—photography was put on watch to find out



Photography adds striking realism to highway poster.

In the hands of Alfred Politz Research, Inc., camera and film sampled the traffic, spaced test periods, stayed on the job, never got tired and reported with complete accuracy.

You can gauge a magazine's readers by its circulation—or a newspaper's by its daily sales. But how can you measure the potential audience of an outdoor poster?

Alfred Politz Research, Inc. worked out an answer. Figuring that anyone the poster can "see" can see the poster, they set up an automatic camera which recorded periods of passing traffic at regular intervals. Counting the people and cars on the film records gave accurate figures on the viewers of the poster and made it possible to compute its gross man-hours of exposure.


Counting people comes as easily for photog-

raphy as counting phone calls, metal rods or tons of coal. It is one of the many ways it is serving all kinds of business and industry. In small businesses and large it is helping to save time, cut costs, reduce error, design new products and improve production.

Graduates in the physical sciences and in engineering find photography an increasingly valuable tool in their new occupations. Its expanding use has also created many challenging opportunities at Kodak, especially in the development of large-scale chemical processes and the design of complex precision mechanical-electronic equipment. Whether you are a recent graduate or a qualified returning serviceman, if you are interested in these opportunities, write to Business & Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

Kodak

Eastman Kodak Company, Rochester 4, N. Y.



Challenging careers in G-E sales engineering

Combine engineering know-how with customer contact work*

For professional careers with unlimited opportunity, investigate G.E.'s Apparatus Sales Training Program. You're trained in the branch of industrial selling most suited to your interests and aptitudes, such as Sales Engineering, Application Engineering, or Product Specialization.

As a G-E representative in one of the Company's 152 Apparatus Sales Offices in key cities, you work with customers to determine what design, new development or system will best serve their needs. The program offers—in addition to exciting district work—career opportunities in the Company's headquarters marketing and sales operations.

SJ-526

*ILLUSTRATION: Sales Engineer and customers discuss turbine rotor construction. Glasses are factory safety measure.

Progress Is Our Most Important Product

GENERAL  ELECTRIC

MAIL COUPON FOR FULL INFORMATION

MANAGER—SALES TRAINING
BUILDING 2
GENERAL ELECTRIC COMPANY
SCHENECTADY 5, N. Y.

Please send me your descriptive bulletin on the Apparatus Sales Training Program, GEZ-515A.

NAME

COLLEGE DEGREE
& YEAR

ADDRESS